draft

NUREG-0341

environmental statement

related to operation of

MOAB URANIUM MILL

Atlas Minerals Division
Atlas Corporation

NOVEMBER 1977

Docket No. 40-3453

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NUREG-0341

DRAFT ENVIRONMENTAL STATEMENT

related to the

Atlas Minerals Division, Atlas Corporation

ATLAS URANIUM MILL

(GRAND COUNTY, UTAH)

prepared by the

U. S. Nuclear Regulatory Commission
Washington, D. C.   20555

November 1977

SUMMARY AND CONCLUSIONS

This draft environmental impact statement was prepared by the staff of the U. S. Nuclear Regulatory Commission and issued by the Commission's Office of Nuclear Material Safety and Safeguards.

1. This action is administrative.

2. The proposed action is the continuation of Source Material License SUA-917 issued to Atlas Corporation for the operation of the Atlas Uranium Mill in Grand County, Utah, near Moab (Docket No. 40-3453). This authorizes a 600-ton (450-MT) per day acid leach circuit (for recovery of vanadium as well as uranium) and a 600-ton (450-MT) per day alkaline leach circuit (for other ores, including copper-bearing ores).

3. Summary of environmental impacts and adverse effects:

   a. The Atlas mill has been in operation since 1956. Impacts to the area during the nearly 20 years of operations have included:

      - Alteration of approximately 200 acres (80 ha) of sagebrush-grassland to milling activities, including the tailings storage pond.
      - Increase in the existing background radiation levels as a result of continuous but small releases of uranium, radium, radon, etc., during mill operation.
      - Socioeconomic effects on Moab and other nearby areas which house (or have housed) workers from the mill.
      - Extraction of approximately 33,792 tons (30,650 MT) of U_3O_8, resulting in approximately 8 million tons (7.2 million MT) of tailings material.[1]

   b. The mill site has been altered from the natural state by milling activities. Continued operation of the Atlas mill would not require the disturbance of additional lands beyond the approximately 200 acres (80 ha) presently committed to the project. The area devoted to the mill itself would be reclaimed after operations cease, but the 115-acre tailings area, under present reclamation plans, must be considered unavailable for further productive use.

   c. Surface water will not be affected by normal operations. Mill process water is recycled from the tailings ponds and supplemented by withdrawals from the Colorado River. Makeup water used by the mill totals 121 gpm (241,000 m^3/yr).

   d. There will be no discharge of liquid or solid effluents from the mill and tailings site. The discharge of pollutants to the air will be small and the effects negligible. The estimated annual whole-body and organ dose commitments to the population of Moab, Utah, are presented below. Natural background doses are also presented for comparison. These dose estimates were based on projected population in the year 1990. The population dose commitments due to normal operations of the Atlas mill represent only very small increases in the population radiation dose-rates from background radiation sources.

Annual Population Dose Commitments (man-rem/year)
to Population of Town of Moab in the Year 1990

	Mill Effluents	Natural Background
Total body	0.2	750
Lung	9	1350
Bone	3	900
Bronchial epithelium	140	7500

e. Continued operation of the Atlas mill requires the commitment of small amounts of chemicals and fossil fuels relative to their abundance.

f. Continuation of the Atlas mill will provide ongoing employment and induced economic benefits for the region.

4. Principal alternatives considered are:

   a. Alternative sites for the mill
   b. Alternative mill processes
   c. Alternative reclamation and stabilization plans
   d. Alternative of no action on relicensing of existing mill

5. The following Federal, state, and local agencies have been asked to comment on this environmental statement:

   Council on Environmental Quality
   Department of Commerce
   Department of the Interior
   Department of Health, Education and Welfare
   Federal Energy Regulatory Commission
   Department of Energy
   Department of Transportation
   Environmental Protection Agency
   Department of Agriculture
   Advisory Council on Historic Preservation
   Department of Housing and Urban Development
   Office of the Governor, State of Utah
   State Planning Coordinator, State of Utah
   Department of Agriculture, State of Utah
   Department of Environmental Quality, State of Utah
   Department of Game and Fish, State of Utah
   Board of Commissioners, Grand County, Utah

6. This draft environmental impact statement was made available to the public, to the Council on Environmental Quality, and to other specified agencies in November 1977.

7. On the basis of the analysis and evaluation set forth in this statement, it is proposed that the renewed license issued for the Atlas uranium mill be subject to the following conditions for the protection of the environment:

   a. If the applicant desires to raise the height of the tailings impoundment in the future, a separate request to amend the Source Material License will be required. Any such construction must utilize methods that satisfy the safety criteria of the NRC.

   b. The applicant will establish an emergency response capability to travel to the scene of any accident involving shipment of yellowcake, in order to minimize release to the environment and to recover any spilled yellowcake. The response plan will be formally documented, and subject to NRC approval. A yearly exercise of this quick response team will be conducted.

   c. The applicant will minimize the problem of airborne particulates from the dried-up areas of the tailings pile by any of several viable dust-suppression alternatives, including chemical methods (use of crusting agents) or such physical methods as keeping the pond surface wet through tailings discharge and/or water sprinkling, covering it with earth, or covering it with other dust-reduction materials, subject to NRC approval.

   d. The applicant will implement additional environmental monitoring programs (Table 6.4) to determine background radiation rates in the vicinity of the mill and to monitor chemical seepage from the tailings area. The applicant shall establish a control program that shall include written procedures and instruction to control all environmental monitoring prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of these envorinmental controls. The applicant shall maintain sufficient records to furnish evidence of compliance with these environmental controls.

   e. Before engaging in any activity not evaluated by the NRC, the applicant will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated, or that is greater than that evaluated in this environmental statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of the NRC for the activity.

f. Prior to disturbing any presently undisturbed soils for mill operations in the future, the applicant shall have an archeological survey conducted of the site(s) to be disturbed.

g. If unexpected harmful effects or evidence of irreversible damage not otherwise identified in this statement are detected during operations, the applicant shall provide to the NRC an acceptable analysis of the problem and a plan of action to eliminate or reduce the harmful effects or damage.

h. The applicant will provide for stabilization and reclamation of the mill tailings disposal areas as described in Section 3.2.5.

i. The applicant will provide for mill decommissioning and mill site reclamation as described in Section 3.2.6.

8. Position of the NRC:

The proposed position of the Nuclear Regulatory Commission is that, after weighing the environmental, economic, technical, and other benefits of the continued operation of the Atlas Uranium Mill against environmental and other costs, and considering available alternatives, the action called for under the National Environmental Policy Act of 1969 and 10 CFR 51 is the renewal of the source material license SUA-917 subject to conditions 7, a through h above.

As announced in a Federal Register notice dated 3 June 1976 (41 FR 22430), the NRC is preparing a generic environmental statement on uranium milling. Although it is the NRC's position that the tailings impoundment method discussed in this statement represents the most environmentally sound and reasonable alternative now available, any NRC licensing action will be subject to express conditions that approved waste generating processes and mill tailings management practices may be subject to revision in accordance with the conclusions of the final generic environmental impact statement and any related rule making.

Reference

1. "Tailings Management and Reclamation Alternatives Study for Atlas Minerals Mill at Moab, Utah," Supplement to Environmental Report, Dames & Moore, Job No. 05467-019-06, July 29, 1977.

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FOREWORD

This draft environmental impact statement is issued by the U. S. Nuclear Regulatory Commission (NRC), Office of Nuclear Material Safety and Safeguards, in response to the request by Atlas Corporation for the renewal of NRC (AEC) Source Material License No. SUA-917, authorizing continued operation of the Atlas Minerals Uranium Mill. This draft statement has been prepared in accordance with Commission regulation 10 CFR Part 51, which implements requirements of the National Environmental Policy Act of 1969 (NEPA). The mill is owned and operated by Atlas Minerals, a division of the Atlas Corporation.

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR 51, the NRC Division of Fuel Cycle and Material Safety prepares a detailed statement on the foregoing considerations with respect to each application for a source material license for a uranium mill.

In accordance with 10 CFR Part 40, Section 40.31, the applicant has submitted an environmental report to the NRC for license renewal and related Federal actions. In conducting the required NEPA review, Commission representatives (staff) met with the applicant to discuss items of information in the environmental report, to seek additional information that might be needed for an adequate assessment, and generally to ensure that the Commission has a thorough understanding of the project. In addition, the staff sought information from other sources to assist in the evaluation, conducted field inspections of the project site and surrounding area, and met with

State and local officials charged with protecting State and local interests. On the basis of the foregoing activities, and other such activities or inquiries as were deemed useful and appropriate, the staff has made an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA.

That evaluation has led to the issuance of this draft environmental statement by the Office of Nuclear Material Safety and Safeguards. The statement has been distributed to Federal, State and local governmental agencies, and other interested parties, for comment. A summary notice has been published in the Federal Register regarding the availability of the applicant's environmental report and this draft environmental statement. Comments should be addressed to

Director, Division of Fuel Cycle and Material Safety
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

After comments on the draft statement have been been received and considered, the staff will prepare a final environmental statement that includes discussion of questions and comments submitted by reviewing agencies or individuals. Further environmental considerations are made on the basis of these comments and combined with the previous evaluation; the total environmental costs are then evaluated and weighed against the environmental, economic, technical, and other benefits to be derived from the proposed project. The consideration of available alternatives and environmental costs and benefits provides a basis for denial or approval of the various Federal actions, with appropriate conditions to protect environmental values.

Single copies of this statement, NUREG-0341, may be obtained by writing:

Division of Document Control
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

1. INTRODUCTION

1.1 THE APPLICANT'S PROPOSAL

Pursuant to Title 10, Code of Federal Regulations (CFR) Part 40, Sections 40.31 and 40.32(e), and to 10 CFR Part 51, Atlas Corporation on 31 August 1973 applied to the Nuclear Regulatory Commission (NRC) for renewal of NRC Source Material License No. SUA-917, authorizing continued operation of the Atlas Minerals uranium processing mill (Atlas) for a five-year period. The mill is currently operating under the timely renewal provisions of Section 40.43 of 10 CFR Part 40.

1.2 BACKGROUND INFORMATION

1.2.1 Present Milling Operations

The Atlas uranium mill is located three miles (5 km) northwest of the city of Moab in Grand County, southeastern Utah (Fig. 1.1). The plant property is bounded by the Colorado River and U. S. Highway 163, and extends across Utah Highway 279 on the west and southwest side. The property consists of approximately 400 acres (160 ha), of which the mill site and tailing area presently occupy approximately 200 acres (80 ha).

Since its start-up in October 1956, the mill has processed ores from the Big Indian area and from small private mines from other districts. During the period of 1956-1972, the number of independent shippers has ranged from about 20 to 70, and the mill is the only processor available within reasonable trucking distance of many of these mines. The main ore bodies producing the present high-lime mill feed are approaching exhaustion. Atlas has recently discovered and acquired deposits of uranium- and vanadium-bearing ore that are within economic shipping distance of the mill. However, the ore cannot be processed in the existing alkaline-leach circuit, because the vanadium content would be lost. The new acid-leach circuit (replacement for one destroyed by fire in 1968) is designed for a nominal 600 tons (545 MT) of vanadium-bearing ore each day.

These ores assay about 0.25% uranium oxide (U_3O_8) and 1.5% vanadium oxide (V_2O_5). Recoveries of V_2O_5 and U_3O_8 will be about 80% and 96%, respectively. The original acid circuit could process 400 tons/day (360 MT/day) of vanadium-bearing ore.

The existing alkaline-leach circuit was originally designed to process 1500 tons (1400 MT) daily of high-lime and copper-bearing ores, although depletion of the ore bodies has forced reduction of the processing rate. The modifications proposed for this circuit will permit Atlas Minerals to retain its custom milling capability for private mines producing alkaline ores while economically phasing out the company mines producing such ores. Most of these ores assay at 0.20% to 0.25% U_3O_8, and some contain up to 1.0% copper. Recovery of U_3O_8 will be about 94%; recovery of copper will be about 80%.

The daily average operating rate of 600 tons/day (545 MT/day) acid-leach ore and 600 tons/day (545 MT) alkaline-leach ore are expected to yield the following concentrates from the modified facility:

921 tons (836 MT) U_3O_8 per year [526 (477) from the acid-leach circuit]

2628 tons (2376 MT) V_2O_5 per year

55 tons (50 MT) copper per year

The tailings and other solid wastes (approximately 1200 tons or 1090 MT per day) will be added to the existing tailings storage. Atlas is continuing its ore exploration program; new discoveries, or additional purchases, could extend the plant life, which is currently estimated at 15 years.

The Atlas mill has been in operation for approximately 20 years, and many of its initial short-term adverse environmental impacts have been compensated for, e.g., certain socioeconomic factors, siting selection, and land disturbance. Accordingly, the scope of this review gives

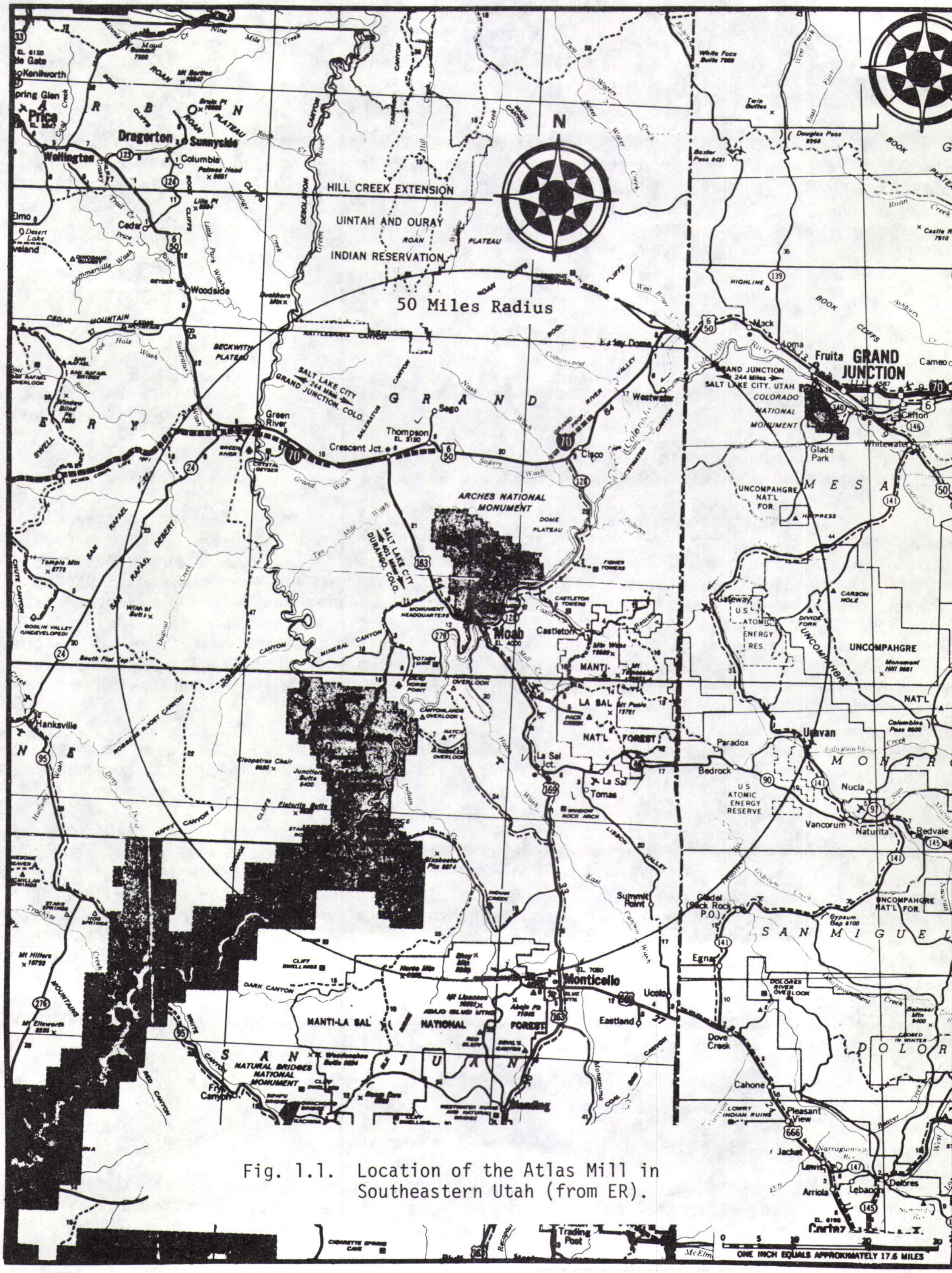

Fig. 1.1. Location of the Atlas Mill in Southeastern Utah (from ER).

greater weight to current operating experience and to those data that will enable a determination of ongoing environmental effects and their mitigation.

1.2.2 Proposed Changes in Milling Operations

The applicant is modifying the existing Atlas mill facilities in the following manner:

1. Construct an acid-leach processing circuit to replace the uranium-vanadium circuit destroyed by fire in December 1968. (Complete.)

2. Revise the existing alkaline-leach processing circuit to reduce liquid effluents to the tailings pond. (80% complete.)

3. Eliminate direct discharge of any effluent streams into the Colorado River by:

   a. Redesigning the plant processes to maximize recycling of mill solutions.

   b. Disposing of the sludge from the river-water treatment plant in the tailings pond instead of the river.

   c. Evaporating excess liquid that may accumulate in the tailings pond. If necessary, an additional holding (evaporation) pond will be provided for the evaporation of excess liquid.

   (Discharge to Colorado River stopped in July 1977.)

1.3 FEDERAL AND STATE AUTHORITIES AND RESPONSIBILITIES

Under 10 CFR 40, an NRC license is required in order to "receive title to, receive, possess, use, transfer, deliver ... import ... or export ... source material ...." (i.e., uranium, and/or thorium in any form, or ores containing 0.05% or more of uranium, thorium, or combination thereof). 10 CFR Part 51 provides for the preparation of a Detailed Environmental Statement pursuant to the National Environmental Policy Act of 1969 (NEPA) prior to the issuance of an NRC license to authorize uranium milling.

The NEPA became effective on 1 January 1970. Pursuant to Section 102(2)(C) of the Act, in every major Federal action significantly affecting the quality of the human environment, Federal agencies must include a detailed statement by the responsible official on:

1. The environmental impact of the proposed action.

2. Any adverse environmental effects which cannot be avoided should the proposal be implemented.

3. Alternatives to the proposed action.

4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.

5. Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

1.4 STATUS OF REVIEWS AND ACTIONS BY STATE AGENCIES

The mill has been operating with the following permits and agreements:

1. Water allocation permit granted by the State of Utah.

2. Limestone lease and mining rights granted by the State of Utah.

3. Letter of agreement (dated 24 June 1971) with the city of Moab for disposal of the mill's nonradioactive sanitary waste at the city's sewage disposal plant (ER). (See also Sec. 3.2.5.)

4. Simple agreement with a private corporation (Phillips 66, by letter of 15 December 1972) for disposal of used lube oils and grease (ER). (See also Sec. 3.2.5.)

1.5 NRC MILL LICENSING RENEWAL ACTIONS

In June 1976, the NRC stipulated that all operating uranium mills that had not yet received a full NEPA review, and for which Environmental Statements had not yet been prepared, would receive this review as part of their source material license renewal procedure.[1] This Environmental Statement constitutes the first environmental analysis of the Atlas milling operations. Data for the analysis have been sought by the NRC staff from a variety of sources that include site visitation, oral and written statements, testing and sampling reports, published literature, and documentation supplied by the applicant. In accordance with NRC Guides 3.5 and 3.8, Atlas Corporation submitted a Source Material License Application (SML, Form AEC-2), an Environmental Report (ER, dated 31 August 1973),*[2] and supplements to the ER in response to questions by the NRC staff.

In its June 1976 statement,[1] the NRC specified that applicants requesting a license renewal prior to the issuance of the NRC generic environmental impact statement on the Commission's uranium milling regulatory program (in progress) should address five factors that will be weighed and balanced by the Commission in its relicensing decisions. The following comments address each factor as it applies to the Atlas mill.

1. It is likely that each individual licensing action of this type would have a utility that is independent of the utility of other licensing actions of this type.

   This statement is true for uranium mills in general, including the Atlas mill. The mill is located in a region which has sources of ore, and is independent of other milling operations.

2. It is not likely that the taking of any particular licensing action of this type during the time frame under consideration would constitute a commitment of resources that would tend to significantly foreclose the alternatives available with respect to any other individual licensing action of this type.

   None of the materials involved in the operation and modification of the mill is unique or in short supply. The relicensing would not affect a licensing action with respect to other new or existing mills.

3. It is likely that any environmental impacts associated with any individual licensing action of this type would be such that they could adequately be addressed within the context of the individual license application without overlooking any cumulative environmental impact.

   This environmental statement contains an evaluation of environmental impacts associated with the proposed licensing action, and their severity, and includes requirements for monitoring programs and other actions to mitigate the impacts. Cumulative impacts have been addressed within the context of the individual license. Long-term effects of the tailings impoundment will be evaluated in this site-specific environmental statement and will also be evaluated in a forthcoming NRC generic environmental statement. The major objective of the generic statement is the generation of proposals to mitigate such impacts.

4. It is likely that any technical issues that may arise in the course of a review of an individual license application can be resolved within that context.

   The staff has reviewed the applicant's evaluations and, in addition, has evaluated other technical issues. All of these evaluations and, presumably, any further technical issues which may arise during review are resolvable within the context of the individual licensing action, inasmuch as this mill is independent of other mills. In addition, the license will be conditioned as required by the June 1976 statement[1] to permit revision of waste generation and management practices, etc.

5. A deferral on licensing actions of this type would result in substantial harm to the public interest as indicated above because of uranium fuel requirements of the operating reactors and reactors now under construction.

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*Cited hereinafter as the ER, giving specific section or page number, etc.

As stated in the June 1976 statement[1] by the NRC, "the full capacity of the existing mills will be required to support presently operating nuclear power reactors and those expected to begin operation in 1977." Therefore, a reduction in the continued output of yellowcake by the Atlas mill at its present rate is considered to be harmful to the public interest. (See also App. B.)

References for Section 1

1. "Uranium Milling, Intent to Prepare a Generic Environmental Impact Statement," Federal Register, Vol. 41, No. 108, 22430-31, June 3, 1976.

2. "Environmental Report Atlas Uranium Mill, Moab, Utah, Atlas Minerals, Division of Atlas Corp., August 31, 1973.

2. THE EXISTING ENVIRONMENT

2.1 CLIMATE

2.1.1 General Influences

The climate of southeastern Utah is dominated by a semi-permanent dome of high pressure located over Nevada and southern Utah. Consequently, deep storm centers--with attendant frontal systems, strong winds, and heavy precipitation--seldom pass through the area. The climate is semi-arid: the mean annual precipitation is 8.2 inches (20 cm); annual snowfall is about 6 inches (15 cm). Precipitation is evenly distributed throughout the year. Summers are hot, with frequent maximum temperatures of 100°F (38°C); winters are moderate, with an infrequent minimum temperature of 0°F (-18°C).[1]

2.1.2 Winds

The prevailing wind direction is westerly to southwesterly, with cold air drainage under very stable conditions from the southeast. Average winds speeds are quite low. Onsite wind speed and wind direction characteristics are given in Table 2.1.

The local topography strongly influences micrometeorological conditions at the site. Moab Valley would be expected to serve as a collection basin for downslope drainage air, resulting in near-calm conditions for the early morning hours. The dilution of airborne contaminants from normal operating releases is determined by the local wind field subsequent to the release.

Figure 2.1 summarizes the bivariate frequency of wind speed and direction as a function of Pasquill stability, which was determined by vertical temperature gradients. Classes A through C represent a composite of unstable periods; classes D, E, F, and G represent neutral, slightly stable, stable, and extremely stable conditions, respectively. Stable conditions result in high concentrations from ground-level releases, and are principally due to cold air drainage down the canyon (SAR, Sec. 2.2.2).

2.1.3 Precipitation

The average annual precipitation at Moab is 8.2 inches, but relatively large annual variations in monthly and seasonal totals take place. Table 2.2 lists monthly median, maximum, and minimum precipitation values at Moab.[2] Potential evaporation exceeds precipitation, averaging approximately 60 inches per year.[3]

2.1.4 Storms

Winter storms--with attendant snowfall, low temperatures, and high winds--are rare. Tornadoes are also rare, and those that have occurred tended to be less destructive than those farther east. No tornadoes have been noted within 50 miles (80 km) of the site since 1950.[4]

2.2 AIR QUALITY

Background data on air quality in the Moab region are lacking. Baseline monitoring has begun at the site, and the actual air quality of the site can be better evaluated when these data become available.

At present, data from Huntington Canyon, Utah [approximately 120 miles (200 km) northwest of Moab] are being used to characterize the air quality of the region.[5] No major pollution sources exist between Huntington Canyon and the site. Suspended particulates at Huntington average about 25 $\mu g/m^3$, or 33% of the national standard; sulfur oxides average less than 10% of the national standards. Thus, it appears that the air quality in the area is presently quite good.

Table 2.1. Joint Frequency of Average Wind Speed and Direction for the Atlas Mill Site, Moab, Utah, November 1974 through May 1975, with 2.7% Calm Distributed in the Table[a]

Direction	Speed, mph 0-3	4-6	7-11	11	Total
N	1.5	0.8	0.4	0.0	2.7
NNE	0.7	0.5	0.1	0.0	1.3
NE	0.6	0.2	0.0	0.0	0.8
ENE	1.3	0.6	0.0	0.0	1.9
E	2.4	0.9	0.7	0.5	4.5
ESE	2.6	1.6	1.7	3.8	9.7
SE	3.3	1.1	1.5	3.0	8.9
SSE	5.1	1.9	0.8	0.9	8.7
S	6.0	2.9	1.2	0.9	11.0
SSW	2.9	2.0	1.4	0.3	6.6
SW	2.1	2.2	2.5	1.6	8.4
WSW	2.3	2.2	4.2	3.9	12.6
W	2.6	3.1	3.8	1.4	10.9
WNW	1.2	1.5	1.8	0.7	5.2
NW	1.2	1.1	0.8	0.3	3.4
NNE	0.9	1.5	1.0	0.0	3.4
	36.7	24.1	21.9	17.3	

[a]Data from SAR, Table 2.2-7.

Table 2.2. Median and Extreme Precipitation (in inches) at Moab, Utah, 1889-1956[a]

Month	Median	Maximum	(Year)	Minimum	(Year)
January	0.48	3.52	1916	0	1919
February	0.60	2.50	1927	T[b]	1933
March	0.68	2.76	1912	0	1934
April	0.80	2.78	1917	0	1939
May	0.55	2.28	1905	T[b]	1911
June	0.32	2.35	1927	0	1954
July	0.48	6.63	1918	0	1954
August	0.79	2.62	1947	T[b]	1950
September	0.56	5.97	1896	0	1953
October	0.83	4.40	1941	0	1952
November	0.65	1.98	1928	0	1932
December	0.66	5.75	1915	0	1930
Annual	8.48	15.96	1927	3.02	1956

[a]From "Climatological Summary, Moab, Utah, Station, Means and Extremes for Period 1926-1955," U. S. Dept. of Commerce, Weather Bureau.
[b]Trace (amount too small to measure).

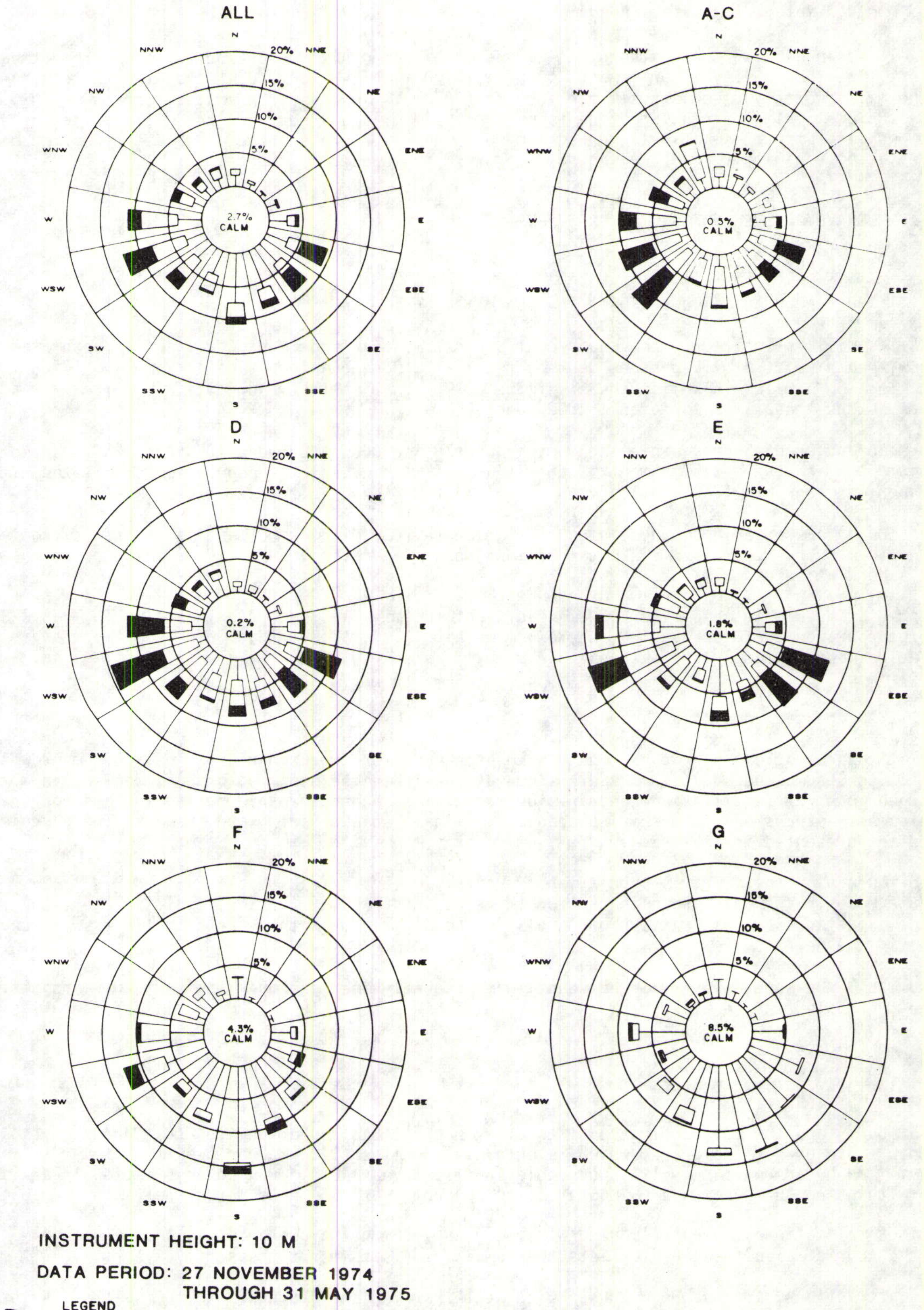

Fig. 2.1. Wind Roses for Various Stability Periods, Atlas Mill Site (from SAR, Fig. 2.2-3) (arrows represent direction <u>from</u> which the wind blows).

2.3 TOPOGRAPHY

The mill is located in the northernmost extension of Moab Valley, just below the mouth of Moab Canyon. The Moab Valley floor is at a 4000-ft (1200-m) elevation. Cliffs on the western border of the mill property rise abruptly for 1000 ft (300 m). To the north and east are 500- to 600-ft (150- to 180-m) high barren sandstone formations. Immediately north of the mill is the southernmost boundary of Arches National Park. The Colorado River crosses the northwest end of Moab Valley at approximately right angles, flowing in a southwesterly direction.

2.4 DEMOGRAPHY AND SOCIOECONOMIC PROFILES

2.4.1 Demography of the Area

2.4.1.1 Current Population and Distribution

The Atlas mill is located in the south-central portion of Grand County, a sparsely populated area with a density of 1.8 persons per square mile.[6] Most people reside in Moab, the County Seat, located 3 miles (5 km) southeast of the mill. Moab is the major city of the region, and serves as the trade area for over 15,000 people.

Both Moab and Grand County experienced rapid population growth between 1950 and 1960, due to the uranium boom and the establishment of the Atlas mill;[7] however, the population stabilized after this period of growth (Table 2.3).

Grand County has experienced declining population (-2.8%) within the last few years--a problem common to many rural areas. The outmigration appears to have occurred in outlying areas, as Moab's population has remained relatively stable.

The population within a 10-mile (16-km) radius of the mill is located principally in Moab and the incorporated area surrounding the town (see Fig. 2.2). Fewer than 50 persons work and reside permanently at Arches National Park.

2.4.1.2 Projected Population and Distribution

Population projections for Grand County have been made for two scenarios. The minimum growth projection assumes no additional factors operating within the economy, gradual decline in mortality, and then constant fertility and net in-migration. The second scenario reflects plans for energy development, expansion and resulting changes in migration and birth rate trends. These projections are presented in Table 2.4.

Three-fourths of the county's population currently reside in Moab (Table 2.3 and Fig. 2.2). Because Moab is the only urban center for the area, and provides various municipal services, it can be expected that this pattern of population concentration within the city limits will continue in the near future.

In summary, the population of Grand County will probably increase over the next 20 years, with three-fourths of the county's residents living within a ten-mile (16-km) radius of the Atlas mill.

2.4.1.3 Transient Population

Grand County and the surrounding counties offer recreational opportunities that draw many tourists to Moab. Arches National Park, which is entered 1.8 miles (2.8 km) northwest of the Atlas mill, was visited by approximately 193,000 people in fiscal year 1975. Canyonlands National Park is also within the surrounding area. Statistics on public use of these parks are given in Table 2.5.

Manti-La Sal National Forest, located within an easy commuting distance, is another heavily visited tourist area. Table 2.6 lists the number of visits for the past five years.

Other attractions, such as Dead Horse Point State Park, Fisher Towers, and the Colorado River, draw many people to the Moab area. In a report[8] published by the Institute for the Study of Outdoor Recreation and Tourism, a regional analysis of Utah non-resident motor vehicle tourism was conducted for Grand and San Juan (located directly south) Counties. These counties, which form the Canyonlands region, were visited by approximately 1,900,000 individuals from June 1974 to May 1975. Tourist visitors to the region spent an average of 0.6 nights, or one-third of their total Utah stay, in the region. Of those who stayed overnight in the region, 13.55%, or 255,187 people, stayed in Moab.

Table 2.3. Population of Moab and Grand County, Utah

	1940	1950	1960	1970	1975
Moab	1084	1274	4682	4793	4810*
Grand County	2070	1903	6345	6688	6500*
Percent living in Moab	52%	67%	74%	72%	74%

*Estimates.

Source: "Environmental Working Paper - Moab, Utah, Partnership Investigation," U. S. Army Corps of Engineers, Sacramento, California, March 1976.

Table 2.4. Population Projections for Grand County, 1980-2000

Year	Low[a]	High[b]
1980	5164	7,978
1985	5390	9,270
1990	5668	9,880
1995	6078	10,239

[a] Y. Kim, "Population Projections by Age and Sex for Utah Counties, 1970-2000," Population Research Laboratory, Utah State University, Logan, Utah.

[b] "Southeastern Utah Coal Developments - 1976," Southeastern Utah Association of Governments, August 1976.

Table 2.5. Visitors to Arches and Canyonlands National Parks, 1974-1975[a]

	Recreational	Non-recreational	Total	Overnight Stays
Arches				
Fiscal 1974	216,200	2400	218,500	29,900
Fiscal 1975	188,000	4300	193,100	33,000
Canyonlands				
Fiscal 1974	60,500	-	60,500	32,700
Fiscal 1975	61,700	-	61,700	28,300

[a] Source: "Public Use of the National Park System: Fiscal Year Report 1975," National Park Service, U. S. Department of the Interior, October 1975.

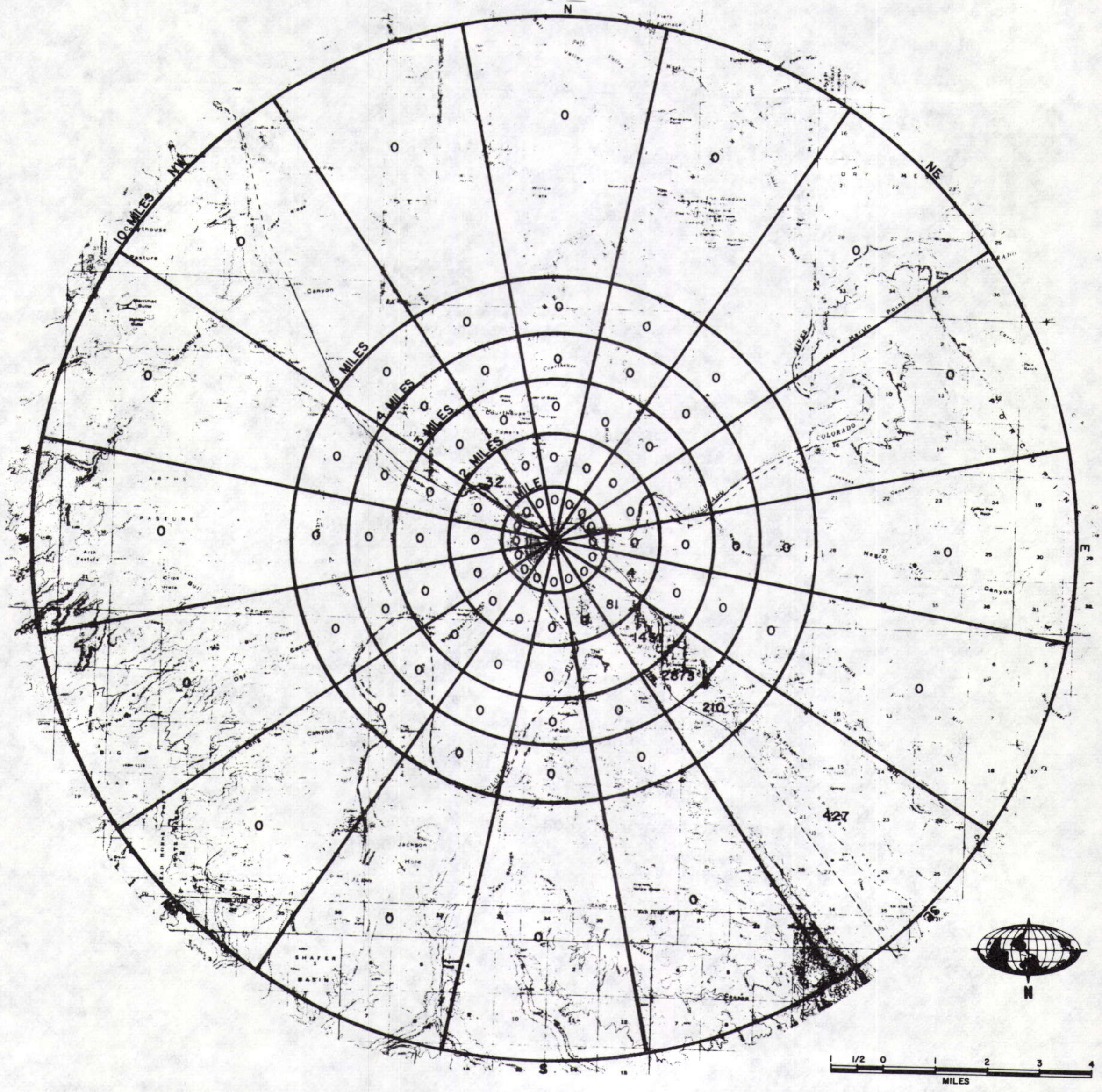

Fig. 2.2. Population (1970 Census) within a 10-Mile Radius of the Mill (from SAR, Fig. 2.1-5).

Table 2.6. Total Visits to Manti-La Sal National Forest, 1971-1975[a]

Year	Visits
1971	198,400
1972	211,800
1973	182,400
1974	178,400
1975	176,100

[a]Source: Forest Service, United States Department of Agriculture, Washington, D. C.

2.4.2 Socioeconomic Profiles

2.4.2.1 Social Profile

Over the 16 years of its operation, the Atlas mill has become integrated into the surrounding community. Its employees live in the area and are a part of its social and economic structure, while the mill is part of the area's economic infrastructure.

Education

The Grand County School District, having offices in Moab, comprises two elementary schools, one middle school, and one senior high school, with a 1976 total enrollment of 1826. The District also provides the Moab Area Vocational Center, which assists multi-handicapped children. Current and estimated enrollments are listed in Table 2.7.[9]

Table 2.7. Enrollments for Grand County School District

School	1970	1975	1976	1977*
Southeast Elementary	640	415	419	427
Helen M. Knight Elementary	505	350	401	409
Grand County Middle School	451	450	430	438
Grand County High School	392	560	565	576
C. R. Sundwall Center	10	15	11	13
Totals	1998	1790	1826	1863

*Estimated.

Southeastern Utah Center for Continuing Education, a division of Utah State University, is located in Moab. Students attending classes at the Center can earn baccalaureate degrees in specific subject areas. For the Fall 1976 term, 353 individuals registered for both credit and noncredit courses at the graduate and undergraduate levels.[10]

Health Facilities

Allen Memorial Hospital, located in Moab, has 38 beds. It has been accredited by the Joint Commission on Accreditation of Hospitals.[11]

The hospital utilizes two ambulances that are owned and operated by the Grand County Ambulance Association, a non-profit organization established by the citizens of Moab. It has been estimated that an ambulance could reach the Atlas mill within seven minutes after receipt of an emergency call (Ref. 12, response to Q. 35).

One of two central offices of the Four Corners Community Mental Health Center is situated in Moab. Two beds are provided at Allen Memorial Hospital for inpatient psychiatric care.[13]

2.4.2.2 Economic Profile

Resource Base

Natural resource development forms a substantial portion of the economic base of the county. Potash is mined at Texasgulf, Inc.'s, Cane Creek mine southwest of Moab, having a production level of 260,000 tons (240,000 MT) annually (1974 figures).[14] Numerous uranium mines are located throughout the county; in addition, many county residents are employed by the Rio Algom Corporation in its uranium mines and mill in San Juan County.[6] Coal mining will become part of the county's economic structure with the opening of the Sego Field, in central Grand County, by Western American Energy Corporation.

The county also has several producers of oil and gas. While not comprising any significant share of the state production (Table 2.8), exploration for new wells continues, particularly around the village of Cisco.[14] With the continual need for energy and natural resources and the abundance of natural resources within the county, natural resource development will continue to have a strong economic impact throughout the county.

Tourism is the other major economic activity in the county. Expenditures by nonresidents in the Canyonlands region (which includes Grand and San Juan Counties) provide over $10 million annually to the region (Table 2.9).

Table 2.8. Oil and Gas Production for Grand County, 1975[a]

Commodity	Quantity	Percent of State Total
Oil	84,368 bbl	0.21
Gas	5,760,543 ft^3	7.56

[a]Source: "Monthly Oil and Gas Production Report, December 1975," Division of Oil, Gas and Mining, State of Utah, Salt Lake City, Utah.

Table 2.9. Expenditures - Canyonlands Annual, 1974-1975[a]

Expenditure Type	State	Region
Tourist Expenditures	$101,167,800	$9,623,900
Business and Other Expenditures	$72,074,300	$1,333,900
All Travel Expenditures	$173,242,100	$10,957,800

[a]Source: "Canyonlands Regional Motor Vehicle Travel," Institute for the study of Outdoor Recreation and Tourism, Utah State University, Logan, Utah.

Even though Moab is a small community, 15% of all overnight stays within Utah in the spring of 1975 were in Moab.[8] As long as tourism remains an active enterprise, it will continue to bring revenue into the area.

Employment

Most people who live in Grand County work in the county, and only three percent of those working in the county reside elsewhere.[15] The Atlas mill, with 161 employees (Ref. 12, response to Q. 33), is the largest industrial employer for the county. This figure does not include people employed by the mines owned by the Atlas Corporation. The next largest industrial facility is Texasgulf, Inc., which produces potash products.[6] The other major employers in the county, both manufacturing and non-manufacturing, are listed in Table 2.10. Approximately 200 Grand County residents are employed by Rio Algom Corporation in its mines and mill in San Juan County.[6]

Employment within the county has risen slightly since 1970. Per capita monthly income has remained \$300 to \$400, which is below the State average (Table 2.11).

Table 2.10. Largest Employers in Grand County, 1976[a]

Name	Services/Products	No. of Employees
Federal, state, county offices	Government	250
Atlas mill	Uranium Milling	161[b]
Grand County school district	Education	130
Texasgulf, Inc.	Potash products	120
Continental Telephone Co.	Communications	60
Moab Industries	Clothing	50
Carroll's Archery Products	Sporting goods	20

[a]Source: "County Economics Facts-1976: Grand County," Utah Industrial Promotion Division, Salt Lake City, Utah.

[b]Supplied by Applicant.

Table 2.11. Per Capita Annual Income for Grand County and the State of Utah, 1970-1975[a]

Year	Grand County	Utah
1970	\$2800	\$3200
1971	3000	3400
1972	3400	3700
1973	3700	4100
1974	3900	4400
1975	4400[b]	4800[b]

[a]Source: Utah Department of Employment Security, Salt Lake City, Utah, 1976.

[b]Preliminary.

When the State of Utah faced a high rate of unemployment (7.2%) in 1975, Grand County did not seem affected by the recession. The unemployment rate stayed at 5.9%--the fourth lowest rate in the 29 counties, at a time when the national unemployment rate peaked at 8.9%.[16] In April 1976, the Grand County unemployment rate, as reported by the Utah Department of Employment Security, had dropped to 5.0%.

2.4.2.3 Transportation

A necessary requirement for the operation of the Atlas mill is the transportation of ore from mines to the mill by truck. In response to an inquiry by the staff, the applicant submitted a truck traffic model (Ref. 12, response to Q. 37). This model has been found to satisfactorily project both current and future shipments of ore. (The model is summarized in Figure 2.3.)

An average of 90 trips, or 45 round trips, are made by ore trucks each day in deliveries of ore to the mill. Six of these round-trips may be expected to enter from the north along U. S. Highway 163, and the remaining 39 will come from the mining districts in the south. These trucks will average 4467 miles/day (7190 km/day) or approximately 130,000 miles/month. Seventeen percent of the traffic is from the north--760 miles (1220 km) daily or 22,100 miles (35,500 km) yearly--and 83% is from the south--3708 miles (5970 km) daily or 107,900 miles (173,700 km) yearly.

In addition to traffic projected by the model, other traffic not included in the model must be added. As reported by the applicant, an average of 4.6 trips, or 2.3 round trips are made daily (69 trucks per month) by trucks to the mill for shipment of material other than ore. Shipments of yellowcake, vanadium, and copper from the mill require movement by truck. This amounts to about 0.6 trips or 0.3 round trips daily. Approximately five light truck trips are made daily to and from the mill.

To determine the vehicular traffic caused by mill employees, it will be assumed that half of the employees travel alone, while the remainder travel in car pools of two people, for a total of 120 daily round trips or 240 daily trips. Because the employees work a 20-day month and the analysis above is for a 30-day month, the daily traffic of mill employees is spread over 30 days and projected at 80 round trips or 160 trips. With the totals reported above, this amounts to 255.2 trips or 127.6 round trips that are made daily by various vehicles to and from the mill.

The average daily traffic tally for U. S. Highway 163 is taken at the junction of Arches Monument Road, approximately 1.8 miles (2.8 km) north of the mill. In 1975, a total of 1600 vehicles/day passed this survey point. Of these, 420 were Utah passenger cars, 480 were out-of-state cars, 405 were light trucks, and 295 were heavy trucks.

2.5 LAND USE

2.5.1 Land Resources

Approximately 90% of the land in Grand County is administered by Federal (74.04%), State (15.49%), and cities/county agencies (0.01%). The Federal land is managed by several agencies and part of it is an Indian Reservation, in amounts shown in the following breakdown:

Management	Acres	(ha)
Bureau of Land Management	1,433,512	(580,150)
Forest Service	57,527	(23,300)
National Park Service	65,475	(26,500)
Bureau of Reclamation	1,797	(750)
Indian Reservations	200,275	(81,000)
Total	1,758,586	(711,700)

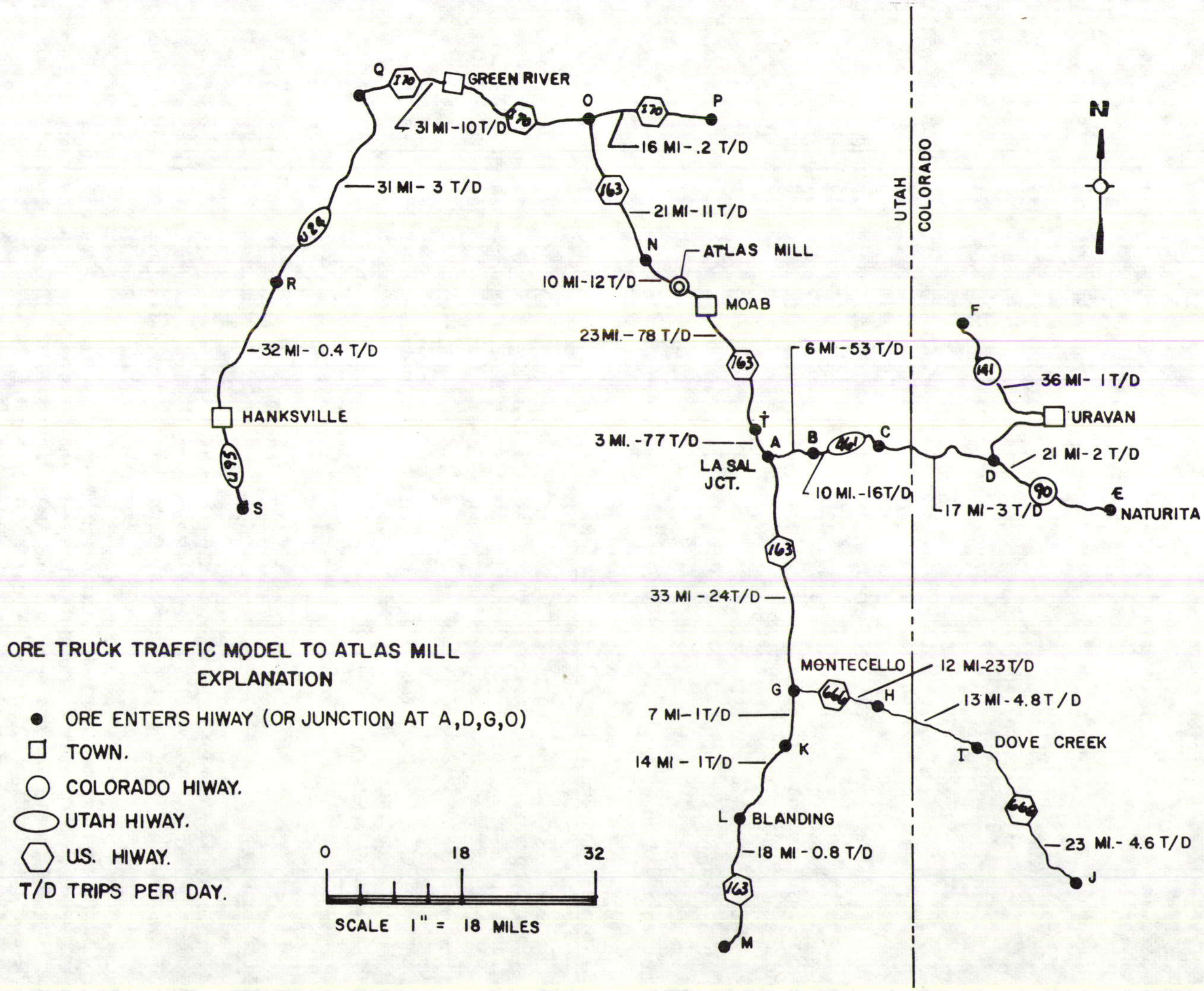

Fig. 2.3. Truck Traffic Model (from Response to NRC Queries of October 28, Q. 37).

2.5.1.1 Mill Ownership

Atlas Minerals Division of Atlas Corporation owns the mill site, which is approximately 400 acres (160 ha). A five-strand barbed wire fence has been constructed along the perimeter of the restricted area. Four rights-of-way across the site (totaling about 50 acres, or 20 ha) have been granted to the Denver and Rio Grande Western Railroad, Utah Power and Light Company, El Paso Natural Gas Company, and Tex's Tour Center (Ref. 12, response to Q. 36).

2.5.1.2 Farmlands

Only limited amounts of land in the area of the mill are suitable for agriculture. Few acres have been farmed:

	1964	1969	1974
Number of farms	74	39	42
Total acres (ha) in farms	157,485	164,339	163,975
	(63,734)	(66,508)	(66,360)

Source: "County Economic Facts - 1976: Grand County", Utah Industrial Promotion Division, Salt Lake City, Utah.

Near the mill, 217 acres (88 ha) are farmed in Moab, 850 acres (350 ha) are under agricultural and rural residential use in Moab Valley (west of Moab), and 300 acres (120 ha) are under irrigation in Spanish Valley.[12] Orchard fruits and livestock are the prime agricultural products in this area. Insufficient irrigation water has constrained use of the more productive agricultural lands in the Spanish Valley.[7]

2.5.1.3 Urban Areas

The closest urban area, the city of Moab, has been described in Section 2.4.

2.5.2 Historical and Archeological Resources

The area immediately surrounding the mill appears to be devoid of any historical or archeological sites. The appropriate State officials indicate that there are no known sites of historical, architectural, or archeological significance (except those at Courthouse Wash and Mill Creek) within the area. It was suggested that the Atlas mill may be of historic interest in terms of its connection with the uranium boom.[17]

Much of the public land around the mill is parkland. Canyonlands National Park, Manti-La Sal National Forest, Dead Horse Point State Park, and Fisher Towers are all within a 50-mile (80-km) radius of the mill; Arches National Park is within two miles of the mill.

2.6 WATER

2.6.1 Surface Water

The mill is located on a river terrace a few hundred feet northwest of the Colorado River at the northwest end of the Moab Valley. Surface drainage features in the vicinity of the site include the Colorado River, Courthouse Wash, Moab Canyon Wash, Mill Creek, and Moab Marsh (see Fig. 2.4).

The major surface water stream in the region is the Colorado River. A gauging station is located one mile (1.6 km) below its confluence with the Dolores River, about 31 miles (50 km) upstream from the site. The drainage area above this point is 24,100 square miles (62,400 sq km). The average discharge over the 59-year recorded period, 1911-1970, is 7711 cfs (2.1×10^{-6} m^3/sec). The record maximum and minimum discharges are 76,000 and 558 cfs, respectively.

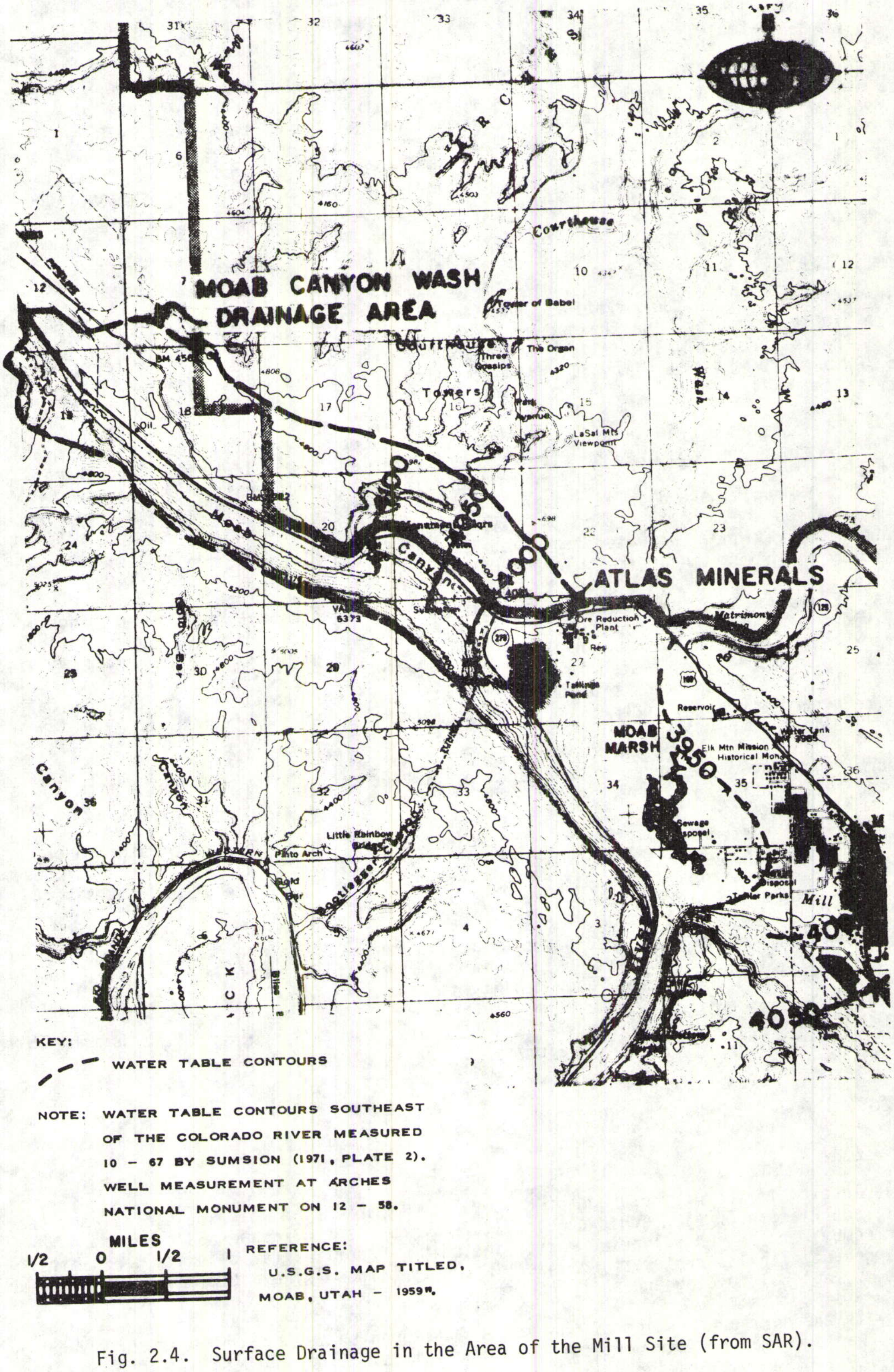

Fig. 2.4. Surface Drainage in the Area of the Mill Site (from SAR).

Courthouse Wash is an intermittent stream that drains an area 102 square miles (260 sq km) north of the mill. Its confluence with the Colorado River is about a half mile (0.8 km) east of the mill. The average discharge is 2.12 cfs (6×10^{-2} m^3/sec), with a record maximum of 12,300 cfs (350 m^3/sec). Moab Canyon Wash is a highly intermittent stream that drains about eight square miles (20 sq km). It cuts across the site, passes the northeast corner of the tailings dike and runs between the tailings pond and the mill. No flood hazards have been observed during the mill's 20-year existence.

Mill Creek drains about 75 square miles (200 sq km) of land south and east of Moab. Its confluence with the Colorado River is about two miles (3 km) southeast of the mill. This creek supplies domestic water for the city and has no influence on mill operations. The average flow is 14.1 cfs (4×10^{-1} m^3/sec). Moab Marsh, located directly across the Colorado River from the mill, spans 650 acres (260 ha), about 150 (60 ha) of which are covered by four feet (1.2 m) of open water. Water area and depth are extremely variable, increasing during spring floods of the Colorado River and sometimes drying up in late summer.

2.6.2 Groundwater

The principal aquifers in the region are the Navajo and Wingate sandstones, where these formations are highly fractured, and the unconsolidated Quaternary deposits that fill the valley bottoms. The thickness of alluvial sediments in the Moab Valley ranges to 360 feet (110 m) and average 70 feet (20 m). The alluvial sediments are the most highly utilized aquifer in the vicinity of the mill.

On either side of the Colorado River, the water table slopes toward the river with a gradient of about 100 ft/mile (20 m/km). At the site, the water table slope decreases to approximately 10 ft/mile (2 m/km) (Fig. 2.5). Recharge to the Moab Valley southeast of the Colorado River is from the La Sal Mountains and is estimated to be 14,000 acre-ft/yr (1.7×10^7 m^3/yr). Recharge to the Moab Canyon area, northwest of the river, is very low due to the light precipitation and high evapotranspiration. The water table level for groundwater in the vicinity of the site is controlled by the elevation of the Colorado River.

All private or public groundwater users are located on an up-gradient from the tailings pond. The only known groundwater use in the vicinity of the site is a well at the Arches National Park headquarters, 1.4 miles (2.2 km) northwest of the site. All water wells and springs within five miles (8 km) of the site are listed in Table 2.3-2 of the Safety Analysis Report (SAR). The locations of test wells and pits provided by the applicant are shown in Fig. 2.6. The mill does not utilize groundwater. All process water is obtained from the Colorado River, and domestic water is supplied by the city of Moab.

The primary groundwater resources other than the alluvium utilized by wells in the mill vicinity include the following:

- Navajo Sandstone - This formation is used primarily for the public water supply of Moab. Depths of the wells range from 106 to 238 feet (32 to 72 m). Estimated yields range from 0.2 to 2445 gpm (1×10^{-5} to 1×10^{-1} m^3/sec), and the water quality is generally high.

- Wingate Sandstone - Because permeability is low, the groundwater recovered is probably through fractures. Yields range from 8 to 36 gpm (5×10^{-4} to 2×10^{-3} m^3/sec) and the water quality is high.

- Cutler Formation - Only four wells in the area top this aquifer. Yields from 15 to 20 gpm (1×10^{-3} to 1.3×10^{-3} m^3/sec).

2.7 GEOLOGY, MINERAL RESOURCES, AND SEISMICITY

2.7.1 Geology

The mill is located in the northern end of Moab Valley (Moab Canyon), in the Canyonlands section of the Colorado Plateau physiographic province (also known as the Paradox Salt Basin). The basin, formed by Permian-Pennsylvanian rocks, including evaporites (salt strata), exhibits several large anticlinal structures and intermingled synclines. The anticlinal structures are the result of regional folding and salt intrusion.

Moab Valley is the northern portion of the larger Moab-Spanish Valley, which is surrounded by high, steep walls formed by near-vertical sandstone cliffs. (The southern portion is called Spanish Valley.) The Moab-Spanish Valley is a remnant of a breached salt anticline whose down-faulted crest has formed an elongated depression. The Colorado River cuts across the anticlinal structure, dissecting the Moab Valley portion.

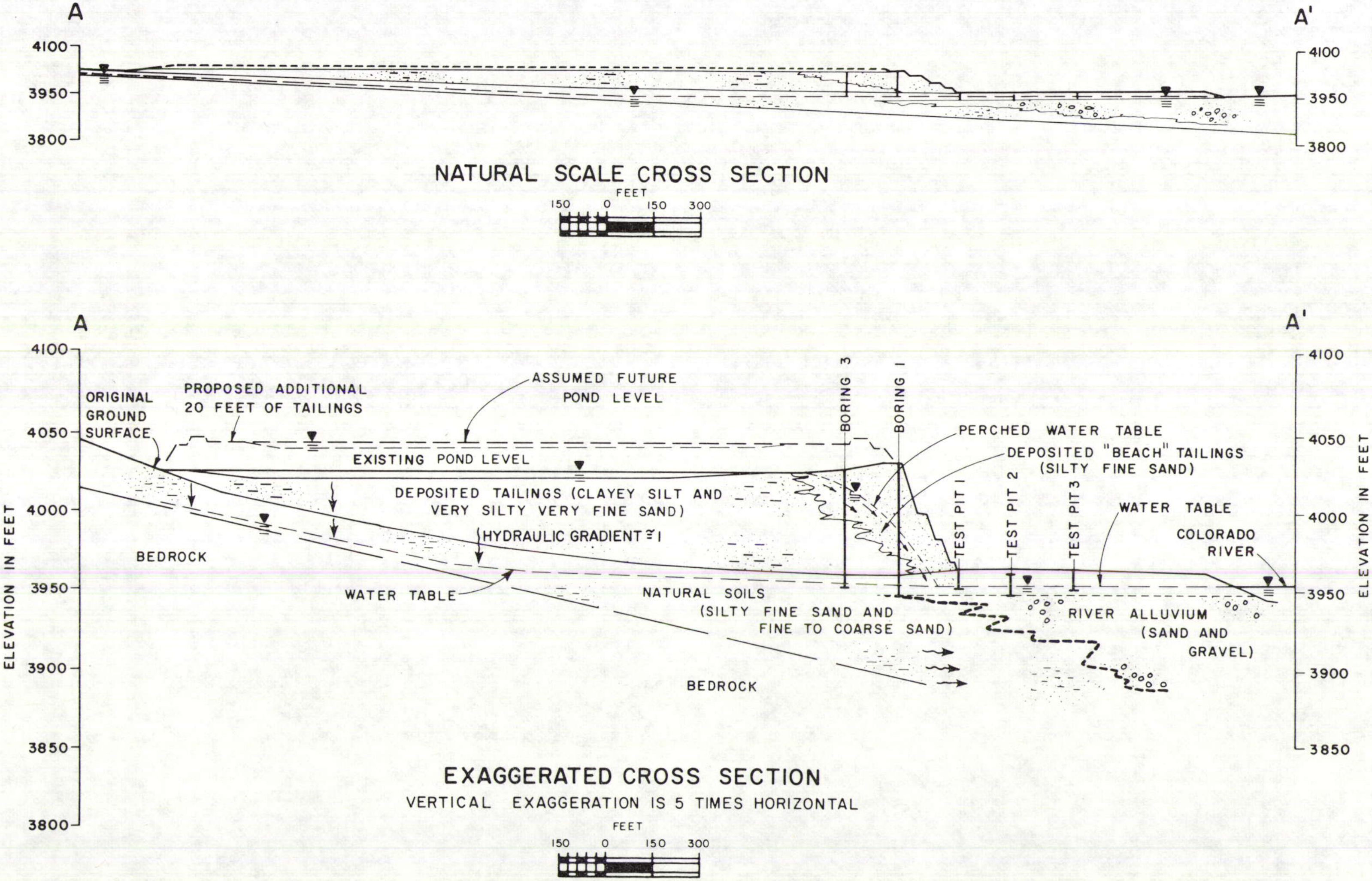

Fig. 2.5. Subsurface Section Showing Movement of Seepage from Tailings Pile (from SAR, Fig. 2.3.4).

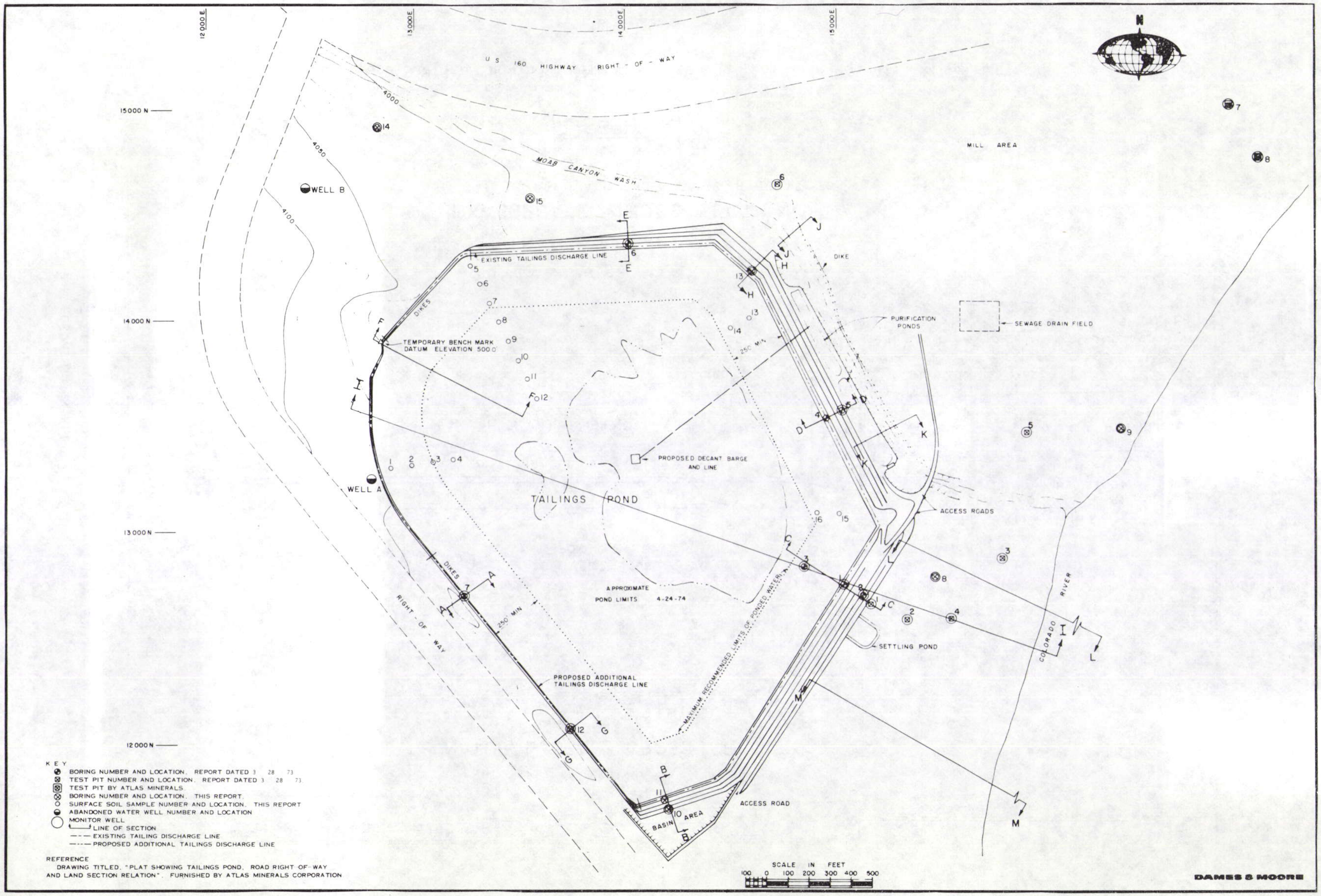

Fig. 2.6. Location of Test Wells and Soil Sample Borings (from ER Suppl. 1).

The collapse of the anticline has been attributed partially to solution and plastic flow of mobilized salt deposits at depth. The valley is bounded on the west and east by faults. The major fault, Moab fault, responsible for the cliffs west of the mill, has many associated smaller faults, some of which are postulated to pass beneath the mill site.

Rocks forming the high cliffs surrounding the valley range in age from Pennsylvanian to Jurassic. Bedrock at the mill site consists of sandstones, conglomerates, and some shales of the Cutler and Rico formations (see Fig. 2.7). The superficial alluvial and slope wash material consist of loose to dense silty sands, sandy gravels, and clayey silts. The soils and subsurface material exhibit considerable variation, both vertically and horizontally, across the site.

2.7.2 Mineral Resources

The major known economically recoverable mineral resources in the region of the Atlas mill include uranium, potash, and oil. Lesser amounts of copper, vanadium, and molybdenum in the uranium ores are of sufficient quantity to be economically recoverable.

The uranium ore mined in the region occurs in the Uravan mineral belt and the Big Indian mining district of the Colorado Plateau. Other uranium milling operations near the mill include the Rio Algom mill, 25 miles (40 km) southeast, and Union Carbide's Uravan (Colorado) mill, 46 miles (75 km) to the southeast. There are numerous other uranium mines or held properties throughout the region.

Potash mining and processing facilities of Texasgulf Inc. are located about seven air miles southwest of the Atlas mill. Oil is being produced from two fields: one near Dead Horse Point, about 12 miles (20 km) southwest of the mill and one in the Lisbon Valley, south of the Rio Algom mill.

2.7.3 Seismicity

The Atlas Mill is located in an area that can expect only minor damage from earthquake activity as plotted on the seismic risk map of the U. S.[18] Recent preliminary maps show the mill region to be in an area where horizontal accelerations will be less than 5% of gravity.[19] There have been 63 recorded earthquakes within 100 miles (160 km) of the mill site, only three of which occurred within 50 miles (80 km) of the mill. The nearest recorded earthquake felt at the mill occurred about 45 miles (70 km) northwest in 1953, and had a Modified Mercalli Intensity of V (SAR, p. 2.4-25).

Additional detailed discussions of the site region geology and seismicity are available in the applicant's Safety Analysis Report, Section 2.4.

2.8 SOILS

The mill site lies wholly on Quaternary undifferentiated sand, residual mantle, slope wash, and alluvium on the floor of Moab Valley. The superficial layers are of recent origin, and are apparently still accumulating. The soils are Entisols, with little or no evidence of the development of pedogenic horizons. Less is known about site-specific soils than about the subsurface material. Thus, the general characteristics of the soil taxa that probably occur will be discussed.

The subsurface conditions may be of significance to the assessment of erosion (Sec. 4.5), and are therefore discussed here. Data from onsite surveys conducted by the applicant (SAR, Sec. 2.4.1.2.2), and from laboratory and field testing (SAR, Sec. 2.4.1.2.5), form the basis for the following discussion.

The depth of the unconsolidated overburden is presumed to be about 100 feet (30 m) (SAR, Sec. 2.4.1.2.2); borings to depths of 50, 62, and 70 feet (15, 19, and 21 m) did not encounter any consolidated material (SAR, Figs. 2.4-9d and 2.4-9h, borings Nos. 15, 8, and 14, respectively). The staff derived its speculative analysis of the sources of the Quaternary deposits at the Atlas site (see Fig. 2.5) from the horizontal and vertical distributions of textural grades encountered in Atlas borings (SAR, Fig. 2.4-9) and on the straight vertical aerial photograph given in Figure 3 accompanying Query No. 8 of Ref. 12. Most of the material under the tailings pond is reddish-brown silty fine sand, grading from loose toward the foot of the cliffs to medium dense along the valley centerline, and rising in elevation toward the foot of the cliffs. This material is probably slope wash from the cliffs along the Moab Fault. There

FIGURE 2.4-3

GENERALIZED STRATIGRAPHIC COLUMN

System	Symbol	Unit	Thickness (Ft)	Lithologic Description
Quaternary	Qa, Qt		0-500?	Alluvium, talus, eolian sand, fanglomerate, glacial deposits, Qt indicates terrace deposits
Tertiary	Tgr	Green River Formation		Lacustrine shale, marlstone, occasional fine-grained sandstone; Parachute Creek member contains oil shale
	Tw	Wasatch Formation	1500	Fluvial mudstone and sandstone, occasionally conglomeratic
Cretaceous	Kmv, Tt	Mesa Verde Group	1200	Marine and non-marine sandstone and shale; Tuscher formation (Tt) is conglomeratic fluvial sandstone
	KM	Mancos Shale	4000	Non-resistant marine shale with some marine and non-marine sandstone; contains Ferron sandstone member
	Kd	Dakota Sandstone	50-200	Fluvial sandstone and conglomeratic sandstone with some non-marine shale
	Kbc	Burro Canyon	50-200	Fluvial sandstone and conglomeratic sandstone, lacustrine siltstone, shale and mudstone
Jurassic	Jm	Morrison Formation	400-900	Fluvial and lacustrine mudstone, shale, and sandstone
	Jsr: Js	San Rafael Group	400-750	Summerville formation (Js): gypsiferous mudstone and sandstone
	Jsr: Je			Entrada sandstone (Je): water deposited siltstone and sandstone, and eolian sandstone
	Jsr: Jc			Carmel formation (Jc): muddy sandstone, shale, thin limestone and gypsum
	Jgc: Jn	Glen Canyon Group	550-1100	Navajo sandstone (Jn): crossbedded eolian sandstone
	Jgc: Jk			Kayenta formation (Jk): fluvial siltstone and sandstone
Triassic	Jgc: TRw			Wingate sandstone (TRw): crossbedded eolian sandstone
	TRc	Chinle Formation	200-600	Non-marine siltstone, sandstone, and conglomerate; contains Shinarump conglomerate member
	TRm	Moenkopi Formation	400-1000	Siltstone, fine-grained sandstone
Permian	PIPcr: Pc	Cutler Formation	700-1000	Fluvial arkosic sandstone and conglomerate, quartzose sandstone, and shale; contains White Rim sandstone (Pwr), Organ Rock tongue (Por), and Cedar Mesa sandstone (Pcm) members
	PIPcr: PIPr	Rico Formation	0-600	Marine sandstone and limestone and non-marine sandstone and conglomerate
Pennsylvanian	IPh: IPhp	Hermosa Formation	2000-7000	Upper member: limestone, shale, and sandstone Paradox (middle) member (IPhp): gypsum, shale, limestone and up to 75 percent salt Lower member: shale and limestone
		Molas Formation	0-150	Shale and sandstone redbeds and marine shale, siltstone, and sandstone
Mississippian, Devonian, and Cambrian			1500-2500	Marine shelf deposits: limestone, shale, dolomite, and sandstone
Precambrian				Granite(?), schist(?), and gneiss(?)
			IGNEOUS ROCK	
Tertiary	Ti	Igneous Intrusives		Laccolithic intrusives: diorite porphyry, monzonite porphyry, and syenite porphyry

Fig. 2.7. Generalized Stratigraphic Column, Moab, Utah, Area (from SAR, Fig. 2.4-3).

appears to be a lenticular alluvial deposit of reddish-brown fine to coarse sand and gravel grading to reddish-brown silty fine sand toward the Colorado River, probably deposited by the Colorado River. There also appear to be some lenticular alluvial deposits of reddish-brown silty fine sand and clayey silt and occasional fine gravel and some scattered roots lying above the presumed Colorado River alluvium, and deposited essentially perpendicular to the alluvium, probably along previous courses of the Moab Wash. There should also be some eolian deposits, but these are probably too thin to show up on the logs of the borings, and may be indistinguishable from the presumed slope wash.

Approximately 115 acres (50 ha) of the site is covered with tailings to a depth of nearly 75 feet (25 m). The tailings are described by the applicant (SAR, Sec. 2.4.1.2.2) as light gray to gray and grayish-brown silty fine sand which is very loose to loose, with lenses or layers of soft grayish-brown clayey silt (slimes). Because these tailings and slimes originate from the mill circuits, they contain trace elements and heavy metals, including radionuclides. Along the slopes of the tailings dike, the superficial layer is native fill compacted to medium dense, and composed of reddish-brown gravel in a matrix of silty fine to coarse sand. The bases of the dikes (starter dikes) are comparable to the native fill covering of the dikes.

The staff concludes that the unconsolidated overburden of the Atlas mill site is typical (cf. Ref. 20) of valley floor and terrace deposits in the Canyonlands section of the Colorado River physiographic province. Furthermore, the staff believes that residual mantle deposits on the sandstone substrata near the Atlas site should be similar to that of onsite slope wash, except that these residual mantle deposits are generally very thin. Residual mantle deposits on shales and siltstones seems to be deeper and apparently include a higher percentage of clay-sized particles than the deposits derived from sandstone.[20]

The soils of the Canyonlands physiographic section, which include the Atlas mill site, would probably be classified as members of the great group Torriorthents.[21] Such soils have "little or no evidence of development of pedogenic horizons [soil profile]."[21] The Torriorthents are members of the suborder Orthents, which are "primarily Entisols on recent erosional surfaces."[21]

The characteristics of the great group and of the suborder defined above are consistent with the staff's analysis of the sources of the Quaternary deposits at the Atlas site, so we may tentatively accept the designation of the onsite soils as Torriorthents with reasonable confidence. The same reasoning applies equally well to all of the soils of the Moab Valley exclusive of Moab Marsh and of the alluvium immediately adjacent to the Colorado River. These soils may have a much higher percentage of organic matter than the dry colluvial soils in the valley. The staff cannot with certainty assign these alluvial soils to any taxonomic category.

2.9 BIOTA

2.9.1 Terrestrial

The staff has reviewed the ecological literature (Refs. 20-23) to determine the probable nature of the biotic communities of Moab Valley and their relationship to the regional ecosystems. The discussion of the area's vegetation (Sec. 2.9.1.1) summarizes that literature, and reports also on personal observations of the staff based on previous field work. The discussions of wildlife (Sec. 2.9.1.2) are based on the ER and on the professional experience of the staff.

Vegetation

The mill site is located in a cool, desert environment. The vegetational formation is Great Basin Desert Scrub,[22] which is also called Southern Desert Shrub (ER, Sec. 2.8.1) or the Canyonlands section of the Colorado Plateau floristic division.[23] Desert scrub vegetation can be extremely uniform, but "is the richest part of the Intermountain Region for endemic species," including "two vegetation types which do not develop to such a large extent anywhere else"[23] (see below).

Seven vegetational communities are likely to occur in the non-mountainous areas near the mill site: 1. blackbrush, 2. shadscale, 3. pinyon-juniper, 4. galleta-threeawn grassland (desert grassland), 5. badlands, 6. marsh grassland, and 7. riparian woodland (cf. Ref. 23).

The blackbrush community is found at lower elevations, along the Colorado and Green Rivers.[23] This community may be found in Castle Valley, upstream along the Colorado River from the Atlas mill, and in Jackson Hole, downstream from the mill. However, it does not occur in the north end of Spanish Valley due to the marshy conditions there. This is one of the two unique communities of the Colorado Plateau.

The shadscale community has been designated as an edaphic,* salt-tolerant variant of the Cresote bush community (at lower elevations in southwestern Utah) and of the sagebrush community (at higher elevations in central Utah). This designation is followed in the Atlas ER (p. 2-26), but a more realistic treatment of this community recognizes it as an altitudinal zone in southeastern Utah.[20,23] Following this approach, the vegetation of the plateaus (including Arches National Park) around the Atlas mill site is correctly described as a shadscale community.

At higher elevations, especially in the northern portion of Arches National Park and on Dry Mesa south of Canyonlands National Park, there are extensive pinyon-juniper woodlands. These woodlands are sufficiently remote from the Atlas mill site that the likelihood of impacts due to the mill are negligible.

Large areas in southeastern Utah are occupied by galleta-threeawn grassland communities,[23,24] but the relationship of these to other regional vegetation is unclear.[23] Examples of these communities can be found in Canyonlands National Park,[24] and perhaps in Moab Valley (staff observed grasslands during site visit but did not determine the composition of the grasslands). This community is also one of the unique communities of the Colorado Plateau.

The other three community-types mentioned above are edaphic communities. A badlands community occurs 10 miles (16 km) from the Atlas mill in Arches National Park on clay soils probably derived from Mancos shale. Both marsh grasslands and riparian woodlands occur along the Colorado River.

The staff has determined the approximate distribution of these community-types in the vicinity of the Atlas mill, based on site visits and the staff's interpretation of the aerial photograph supplied as Figure 3 accompanying Query No. 8 of Ref. 12. These distributions are given in Figure 2.8 and Table 2.12.

Table 2.12. Total Acres (ha) Occupied by Various Ecosystems near the Atlas Mill

	Distance from Tailings Pond Perimeter			
Ecosystem Types	0-0.3 Mile (0-0.5 km)	0.3-0.6 Mile (0.5-1.0 km)	0.6-0.9 Mile (1.0-1.5 km)	0-0.9 Mile (0-1.5 km)
Desert grassland	142 (60)	76 (31)	31 (13)	249 (104)
Shadscale	127 (53)	228 (93)	223 (90)	578 (236)
Riparian woodland and marsh grassland	36 (15)	134 (57)	247 (103)	417 (175)
Totals	305 (128)	438 (181)	502 (206)	1245 (515)

Wildlife

The wildlife near the site is probably strongly influenced by topography. Moab Valley, at approximately 4000 feet MSL (1200 m), is separated by 500- to 1000-foot (150 to 300 m) cliffs from the surrounding region. This forms an effective barrier to the movement of many large animals. Hence, although Grand County, Utah, contains suitable habitat for several big game animals, Moab Valley receives little use by large animals. The only big game reported are mule deer, which are only occasionally sighted (ER, Sec. 2.8.2).

Small mammals such as striped skunk, blacktail jackrabbit, cottontail rabbit, small rodents, and some predators are potential permanent residents of Moab Valley (ER, Sec. 2.8.2). Only two bird species are reported (apparently as summer residents) by the applicant (ER, Sec. 2.8.2) for the shadscale communities near the mill site.

*Generally, communities confined to unusual soil conditions.

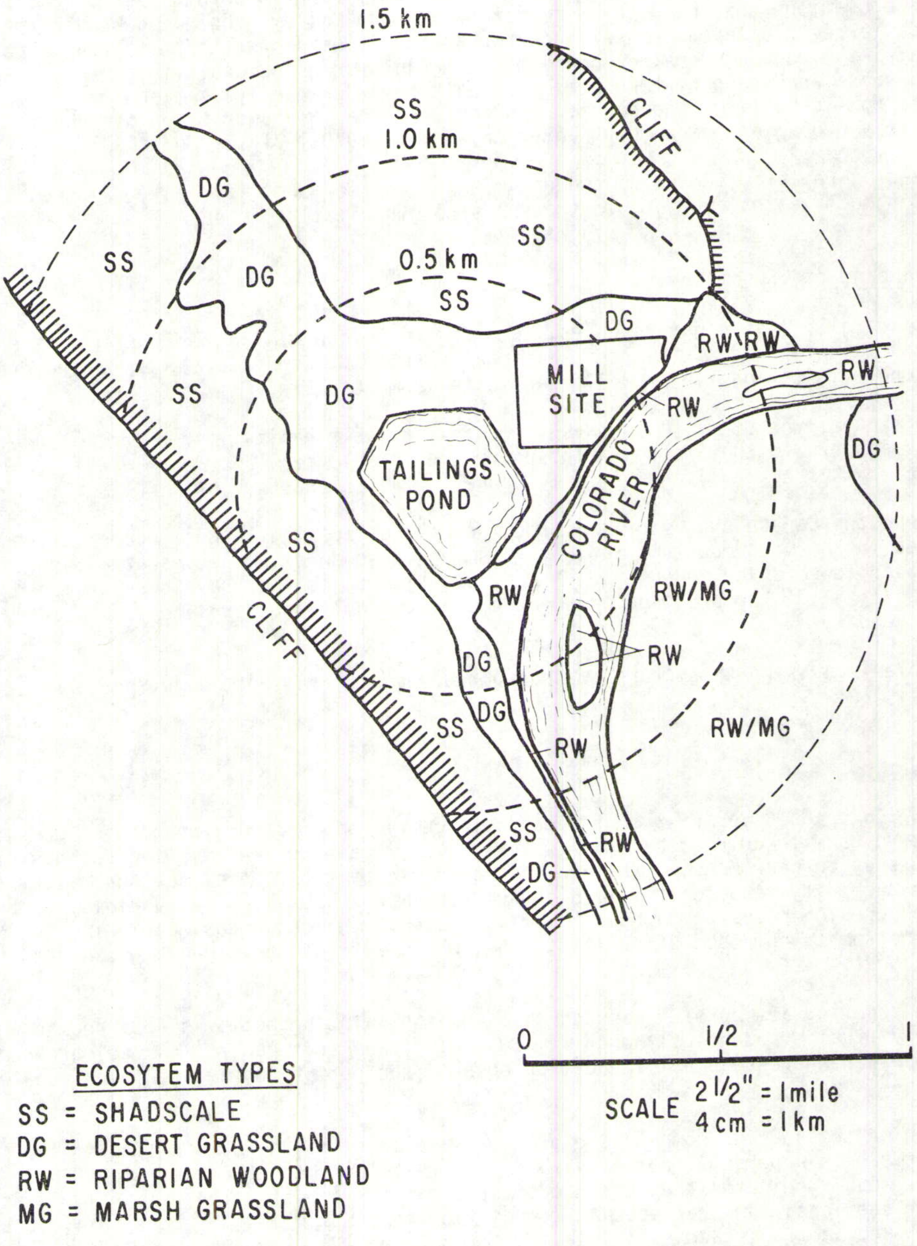

Fig. 2.8. Approximate Distribution of Biotic Communities in the Area of the Mill (circles indicate distance from tailings pond).

The riparian woodlands and marsh grasslands apparently support both denser and more diverse wildlife populations than do other communities of Moab Valley, including beaver and muskrat, six species of terrestrial birds as permanent or seasonal residents, and more than a dozen species of terrestrial birds as normal or occasional migrants or occasional visitors (ER, Sec. 2.8.2). The marsh grasslands support ten species of waterfowl, primarily as migrants. Although the area is open to public hunting, the county reported less than one duck taken per hunter-day and approximately 0.05 geese taken per hunter-day during 1970-1971 (ER, p. 2-30).

Six species of raptors, including the prairie falcon (see Sec. 2.9.1.3), may occur as occasional visitors in Moab Valley, but should show no strong habitat preference.

Rare and Endangered Species

Only one Federally listed rare species, the prairie falcon (*Falco mexicanus*), is reported as "an uncommon permanent resident in Arches National Park" (ER, Sec. 2.8.2), and therefore it may be an occasional visitor onsite as well as offsite in Moab Valley.

In the opinion of the staff, Moab Marsh includes suitable habitat for potential use by three species of concern to the State.[25] These are the river otter (*Lutra canadensis*), white pelican (*Pelecanus erythrorhynchos*) and sandhill crane (*Grus canadensis*).

In addition, the Canyonlands floristic section has perhaps the largest number of endemic species of any area in the Intermountain Region.[23] Among these endemic species are 11 species that have been proposed as rare and endangered,[26] and several species that have been proposed as threatened.[27,28] Of the proposed endangered species, only one (*Cycladenia jonesii*) is reported from Grand County.

Any possible impacts on these rare or endangered species are treated in Sections 4.6.1.2 and 4.7.3.

2.9.2 Aquatic

Much of the Colorado River system has been altered by the construction of high dams that create large reservoirs with cold, clear tail waters. The remaining free-flowing reaches of the river (e.g., the section near Moab, Utah) are characterized by substantial seasonal fluctuations in flow, high turbidity, and relatively high summer temperatures.[29] The turbidity is presumably due to high erosion rates throughout the river basin. In most areas, including the Moab reach, the river bottom is composed of shifting sand, while riffles and bedrock occasionally occur in swifter reaches.

Due to the scouring action of suspended silt and the shifting bottom sands, rooted aquatic plants are virtually absent [although willow (*Salix*) and salt cedar (*Tamarix*) are common in the river floodplain where seasonal inundation occurs] and periphyton and benthic fauna are restricted.[29]

Information on the species composition of algae and invertebrate communities in the Colorado River near Moab is apparently not available. A pre-impoundment study of Glen Canyon[29] (downstream from Moab) indicates that benthic invertebrates are restricted primarily to riffles or rocky river sections, and that species composition consists mainly of mayflies (e.g., *Traverella, Heptogenia,* and *Baetis*), caddisflies (e.g., *Potamyia* and *Neotrichia*), and midges. The most conspicuous algae were periphytic *Cladophora* species and the ubiquitous *Spirogyra* and *Zygnema*, all in the division Chlorophyta (green algae).[29] The study listed 28 species of green algae (Chlorophyta), 20 diatom (Chrysophyta) species, and five species of blue-green algae (Cyanophyta).

As a result of high turbidity, low primary and secondary production, dam construction, and water diversion, the species composition of fish communities in the Colorado River is small. Fewer than 20 species are known to occur, or are likely to occur, near Moab[29-31] (see Table 2.13). The native flannelmouth sucker, and the introduced channel catfish, sand shiner, and red shiner, are the most abundant species, while the fathead minnow, carp, roundtail chub, speckled dace, bluehead sucker, and green sunfish are considered common.[30] The channel catfish is the primary sport and food fish, and angling pressure is considered high (ER). This fish is an omnivore that is known to tolerate a wide range of environmental conditions.

Two endangered fish species are known to occur in the Colorado River near Moab: the humpback chub and the Colorado squawfish.[30] The humpback chub generally prefers swift waters, and apparently was at one time widespread in the Green and Colorado Rivers. The endemic Colorado squawfish is a large predaceous fish usually found in deep, muddy waters where current is evident and vegetation is scarce. It is believed that dam construction and the introduction of other species have inhibited populations of both endangered species.[32]

Table 2.13. Fish Species Known or Likely to Occur in the Colorado River near Moab

Common Name	Scientific Name
Roundtail chub	*Gila robusta*
Humpback chub	*Gila cypha*
Colorado squawfish	*Phytochocheilus lucius*
Speckled dace	*Rhinichthys osculus*
Fathead minnow	*Pimephales promelas*
Carp	*Cyprinus carpio*
Red shiner	*Notropis lutrensis*
Sand shiner	*Notropis stramineus*
Flannelmouth sucker	*Catostomus latipinnis*
Bluehead sucker	*Catostomus discobolus*
Humpback sucker	*Xyrauchen texanus*
Channel catfish	*Ictalurus punctatus*
Black bullhead	*Ictaluris melas*
Rio Grande killifish	*Fundulus zebrinus*
Largemouth bass	*Micropterus salmoides*
Green sunfish	*Lepomis cyanellus*

The discharge of effluents to the Colorado River from the Atlas Mill ceased on 1 July 1977, but past operation of the mill resulted in the discharge of ~ 1000 to 2000 gpm (6×10^{-2} to 1×10^{-1} m^3/sec) of effluent from the facility's radium treatment ponds to the Colorado River. This effluent contained measurable quantities of salts and toxic trace elements. Staff calculations indicate that concentrations of chemical constituents in the river may have been increased 10 to 30% over ambient levels at extremely low river flow (i.e., ~ 500 to 1000 cfs) due to release of the Atlas effluent, but that at average river flow (i.e., ~ 7700 cfs) the increase would not have been detectable.

Because the Atlas effluent was diluted by a minimum factor of 500 at normal low river flow (i.e., ~ 1000 to 2000 cfs or 30 to 60 m^3/sec), it is unlikely that indigenous aquatic biota were substantially affected. It is, however, conceivable that less-soluble metals in the effluent (e.g., Fe, Mn, Cu, Zn, and other heavy metals) may have accumulated in river sediments and aquatic biota immediately downstream from the point of discharge. Because mill effluents will no longer be discharged to the river, the staff believes that metal concentrations in sediments and biota will rapidly return to ambient levels and that no long-term adverse impacts will ensue.

2.10 NATURAL RADIATION ENVIRONMENT

Radiation in the natural environment is due to cosmic radiation, terrestrial radiation, and inhalation of radon and its daughters. The cosmic radiation dose equivalent in Utah is estimated to be about 65 mrem/yr to the whole body.[33-39] The cosmogenic radiation dose equivalent is about 1 mrem/yr, mainly from C-14.[40-43] Terrestrial radiation originates from the radionuclides K-40, Rb-87, and daughter isotopes from the decay series for U-238, Th-232, and, to a lesser extent, U-235. Terrestrial radiation exposure in Utah results in a dose equivalent of about 35 mrem/yr to the whole body.[40,41]

The concentration of radon in the Atlas area is in the range 500 to 1000 pCi/m^3, based on the concentration of Ra-226 in the local soil.[40,44] Exposure to this concentration on a continuous basis would result in a dose of 500 to 1000 mrem/yr[45] to the segmented bronchi. In unventilated enclosures, the lung dose could reach 2000 mrem/yr.

The medical whole-body dose for Utah is about 75 mrem/yr per person.[46] The total dose in the Atlas area from both natural background and medical exposure is estimated to be 180 mrem/yr.

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3. OPERATIONS

3.1 MINING OPERATIONS

Since initial start-up in October 1956, the mill has processed ores from the Big Indian mine and from small private mines in other districts. During 1956-1972, the number of independent shippers has ranged from about 20 to 70. The mill is the only processor available within a reasonable trucking distance of many of these mines. There is no mine associated with the Atlas mill site.

3.2 THE MILL

3.2.1 External Appearance of the Mill

Changes affecting the external appearance of the mill and other facilities will result from (1) the addition of one or two more lifts of the tailings pond dike as required by continuing operations and the covering of these additions with local surface material, and (2) the completion of an improved alkaline leach circuit to allow operation of a zero-discharge milling circuit.

The completed processing plant will have three principal, interrelated sections: the acid-leach circuit, the alkaline-leach circuit, and the copper recovery circuit. In addition, the new acid-leach circuit has facilities for the extraction and recovery of vanadium, which ordinarily would be lost in the alkaline-leach circuit. Figure 3.1 depicts the layout of the various plant facilities, and Figure 3.2 is a block flow diagram of the milling processes. The mill will process about 1200 tons (1090 MT) of ore per day, and produce approximately 921 tons (835 MT) of U_3O_8 (526 tons or 477 MT from the acid leach; 395 tons or 358 MT from the alkaline leach), 2628 tons (2380 MT) of V_2O_5, and 55 tons (50 MT) of copper annually.

3.2.2 The Mill Circuits

The acid-leach circuit is designed to process 600 tons (545 MT) daily of vanadium-bearing ores with an average assay of 0.25% U_3O_8 and 1.5% V_2O_5. Recoveries of V_2O_5 and U_3O_8 are about 80% and 96%, respectively. The modified alkaline-leach circuit will be capable of processing 600 tons (545 MT) of high-lime and copper-bearing ores daily, with an average assay of 0.20 to 0.25% U_3O_8 and up to 1.0% copper. The circuit will recover U_3O_8 and copper at about 94% and 80%, respectively. The estimated daily consumption rates of chemicals and reagents required for ore processing are listed in Table 3.1.

Ores from the Big Indian mining district and from small private mines in other districts are hauled by truck to the mill and stored in the appropriate stockpile area according to origin, uranium content, and chemical composition. They are then fed to the crushing plant, where they are progressively crushed and screened to less than 3/4 inch (2 cm). Crushed ores are stored in cylindrical ore bins that serve as tributaries to the acid-leach and alkaline-leach grinding circuits.

3.2.2.1 Alkaline Circuit

Uranium extraction proceeds when the ore is reduced to sufficiently fine particles to expose the mineral to the extractive reagents. In the alkaline-leach circuit, the ore is wet-ground to -65 mesh with sodium carbonate (Na_2CO_3) solution, resulting in a 50% slurry. The slurry is preheated in heat exchangers and fed into autoclaves, where leaching is accomplished after sufficient retention time by dissolving the uranium in the sodium carbonate solution. The autoclave discharge passes through the hot side of the heat exchangers to preheat the feed going into the leaching section. The solution containing uranium is then separated from the solids by washing, repulping, and filtering in three successive stages using vacuum-drum filters, the liquid and solid flows being counter-current. The resulting pregnant liquor (uranium dissolved in Na_2CO_3) is clarified through pressure filters, and the uranium is precipitated by addition of excess sodium hydroxide (NaOH) and steam in agitated precipitation tanks. The sodium diuranate ($Na_2U_2O_7$)

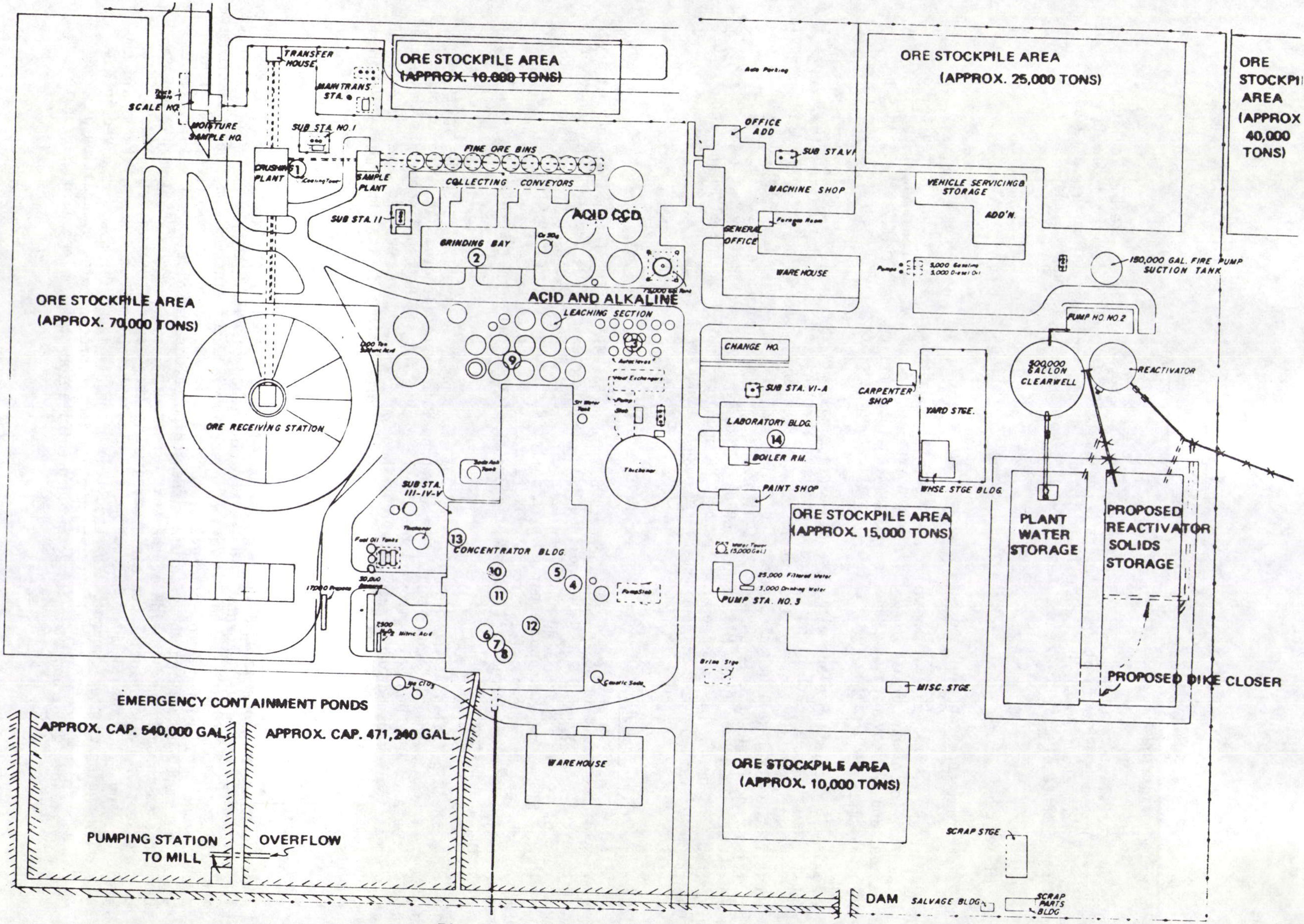


Fig. 3.1. Diagram of Mill Layout (from ER).

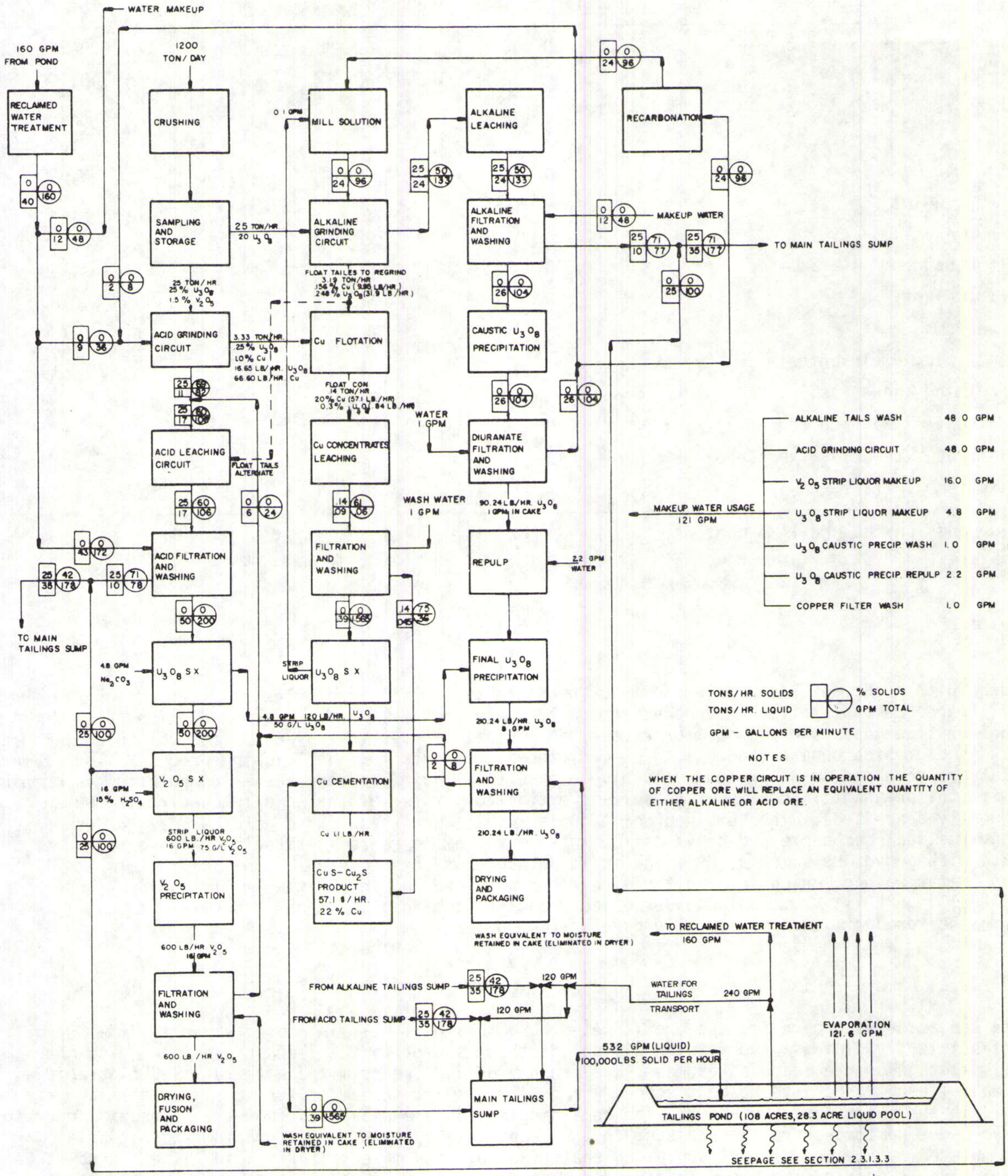


Fig. 3.2. Block Flow Diagram of the Milling Process (with materials balance).

Table 3.1. Estimated Daily Consumption of Chemicals and Reagents

	lb/day			
Reagents	Acid Circuit	Alkaline and Copper Circuits	Other	Total
H_2SO_4, 95 wt %, 66° Bé[a]	240,000-360,000	730		241,000-360,000
NaOH, 50 wt %		40,100		40,100
Anhydrous NH_3[b]			15,000	15,000
Na_2CO_3	9,600			9,600
$NaClO_3$	3,000		3,000	6,000
H_2O_2, 30 wt %		2,100		2,100
MnO_2 (native)		290		290
Iron powder[b]	2,500	650		3,150
Flocculant	90	90	3	183
Guargum	600	580		1,180
Potassium amyl xanthate		15		15
Frothing agent		5		5
Solvent extraction (organic)	120	2		122
Solvent extraction (kerosene)	640	170		810
Aluminum sulfate			8	8

[a]Depends on the ore lime content.

[b]Estimated.

precipitate formed is dewatered in thickeners and vacuum filtered. The thickener discharge and filtrate are sent to the recarbonation tower, where they will absorb carbon dioxide (CO_2) from boiler flue gas. The residual or excess NaOH in solution is thereby converted to sodium carbonate and sodium bicarbonate ($NaHCO_3$) to be recycled as reagents for the leaching process. The filter cake is repulped in water and redissolved in sulfuric acid, and the resulting solution is combined with the pregnant liquor from the solvent extraction system of the acid-leach circuit (subsequently described). The combined solution is acidified with sulfuric acid (H_2SO_4) to decompose any residual carbonate and drive off CO_2 gas. Uranium is reprecipitated by raising the pH to 2.4 with anhydrous ammonia (NH_3) and adding hydrogen peroxide (H_2O_2). The precipitate is filtered and water-washed, dried in a multiple-hearth dryer, crushed in a hammer mill, and packaged in 55-gallon (200-l) drums as a powder or as granules less than 1/4 inch (0.6 cm) in size. This finished product is an essentially pure uranium oxide.

3.2.2.2 Acid Circuit

In the acid-leach circuit, the ore is wet-ground in a ball mill in closed circuit with a spiral classifier, yielding a slurry with 50% solids that is sent to the leaching section. For the first stage of the leaching process, the freshly ground ore is mixed with recycled high-acid leach liquor to achieve reagent economy, and with a small stream of ferric hydroxide slurry to aid in the oxidation of uranium. The remaining solids are separated from the pregnant liquor in cyclones and thickeners and are sent to the second-stage leach, where uranium extraction is completed by the addition of sodium chlorate ($NaClO_3$) and more sulfuric acid. The second-stage leaching is enhanced by steam heating for a retention time of about 21 hours. The resulting discharge is cooled and sent through classifiers and wash thickeners, the overflow being pumped back to the first-stage leach as a sulfuric acid supplement (previously described) and the underflow being sent to the filtration section. The pulp in the underflow is washed, to recover liquids that contain uranium and vanadium, with the aid of three counter-current stages of vacuum-drum filters in series. Two principal streams result: (1) an acid filtrate, containing uranium and vanadium, which is recycled to the leach section classifiers, and (2) a washed filter cake or "tailing," which is repulped to a slurry of 25 to 30% solids and pumped to the tailings pond. The pregnant liquor from the first-stage leach section is clarified, and its uranium content transferred from the "aqueous phase" to the "organic phase" in the countercurrent solvent extraction process. Thereafter, the loaded "organic phase" is stripped of uranium content by contacting with sodium carbonate solution, and the stripped organic solvent is recycled through the extraction process. The pregnant aqueous phase is then combined with the product liquor from the alkaline leach circuit, as previously described, prior to uranium precipitation.

3.2.2.3 Vanadium Recovery

In addition to the pregnant aqueous process stream identified above, a second barren aqueous process stream (the uranium raffinate) containing vanadium leaves the uranium solvent-extraction section of the plant. Vanadium is recovered from this stream by the following steps: (1) adjusting the pH to 2.0 by addition of anhydrous ammonia, (2) extracting vanadium with organic solvent, (3) stripping vanadium from the organic phase with a 15% sulfuric acid solution, and (4) precipitating vanadium by adding steam, sodium chlorate, and ammonia to form a complex vanadium product, principally oxides, referred to as "red cake." The resulting precipitate is thickened; drum-filtered; melted in fusion furnaces; and cast on rotating, water-cooled casting wheels to form a "black oxide" flaked product that is packaged in 55-gallon (200-l) drums.

3.2.2.4 Copper Recovery

Copper is recovered from copper-bearing ores, starting with their grinding in the acid-leach grinding circuit. The ground ores are sent to flotation cells where a copper sulfide (CuS) concentrate is produced with the aid of a frothing agent. The flotation tailings are normally sent to the alkaline-leach regrind mill for uranium recovery. The copper sulfide concentrate is leached with sulfuric acid and sodium chlorate to dissolve its uranium content, then vacuum filtered and washed. The uranium-bearing filtrate is pumped to an existing solvent-extraction circuit, while the filter cake, the major constituent of the copper product, is air-dried in heaps and loaded in bulk on trucks when sold. The raffinate from the SX circuit is depleted in uranium but contains copper dissolved during the uranium leach of the copper sulfide concentrate. This copper is recovered by cementation, in which powdered metallic iron reduces the copper ions in solution, precipitating metallic copper. The precipitated copper is combined with the copper sulfide fraction as a constituent of the final copper product.

3.2.3 Non-Radioactive Wastes and Effluents

3.2.3.1 Gaseous Effluents

A number of non-radioactive gases will be emitted to the atmosphere during ore processing, notably kerosene and organic solvent vapors, CO, CO_2, SO_2, and water vapor. Table 3.2 shows the plant sources, emission points, and emission rates on a volumetric and weight basis for these gaseous effluents. Water vapor and CO_2 account for bulk of the total gaseous releases.

3.2.3.2 Solid Effluents

Aside from the tailings, solid effluents from the mill will consist of airborne particulate emissions in the form of road dust; particulates not captured by dust collectors during ore crushing, sampling, and storage; product particles of drying and packaging; dust from the vanadium furnace; and windblown particulates from ore stockpiles and dried-up areas of the tailings pond. Table 3.3 lists these particulate emission sources, with their corresponding locations and emission rates.

The character of the particulates from the dust collectors and the windblown road dust will depend on the mineral composition of the ores and the local soils. The chemical composition of particulates emanating from the product packaging and drying areas and from the vanadium furnace will be identical to that of the uranium and vanadium products themselves. Typical analyses of the uranium product (yellowcake) and vanadium product are given in Table 3.4.

3.2.3.3 Liquid Effluents

The milling process generates several liquid effluent streams that are ultimately disposed of in the tailings pond. These combined effluents consist of an aqueous medium containing dissolved and undissolved ore solids, excess reagents (such as the free acid from the leaching process), and any remaining dissolved radionuclides. Table 3.5 lists the various liquid effluent streams, their points of origin in the mill, and discharge rates on the basis of their solid and liquid

Table 3.2. Gaseous Effluents[a]

Source	Emission Rate, cfm	Stack Height, ft	Distance to Plant Boundary, ft				Hours Operated per Day	lb/day						
			N	S	E	W		Kerosene & Organic Solvents	CO	H_2O	CO_2	SO_2	H_2	Miscellaneous
Alkaline Leaching (preleach tanks)	5,500	60-75	600	2700	1500	3200	24					0.023[d]		
Copper Cementation	120	75	900	2500	1200	3400	24		2×10^{-6}		20	0.001		
Copper Leach Tanks	1,100	75	900	2500	1200	3400	24					0.15		
Peroxide Precipitation	70	65	1000	2500	1300	3300	24					0.004		
CO_2 Removal	23[b]	75	900	2100	1200	3100	24				5,966			
Acid Leach Tanks	11,000	65	600	2700	1500	3200	24					1.5		
Acid Mix Tanks	1,000	65	600	2700	1500	3200	24					0.15		
U_3O_8 SX and Stripping	-	-	1000	2700	1400	3100	24	90						
V_2O_5 SX and Stripping	-	-	1000	2700	1400	3100	24	90						
Iron Reduction	135[b]	75	900	2600	1300	3300	24						17	
Boiler Stack	7,600[b]	65	800	2800	1500	3200	24			63,000[c]	102,000[c]			
Tailing Pond Evaporation	14,000[b,d]	0	500	500	700	150	24			960,000[d]				
Laboratory	-	65	700	2600	1000	3500	8							2.5

[a]From SAR.

[b]At 1 atm., 15.6° Celsius.

[c]These numbers do not reflect the absorption of CO_2 and H_2O in the carbonation tower, and are therefore too high.

[d]Yearly average.

Table 3.3. Airborne Particulate Emissions[a]

Source	Emission Rate, cfm	Stack Height, ft	Distance to Plant Boundary, ft				Hours Operated Per Day	Particulate Rates, lb/day	Measured or Estimated
			N	S	E	W			
Dust Collectors	66,400	5-10	300	3400	1800	2900	10	63	M
Road Dust	-	-	-	-	-	-	24	c	-
U_3O_8 Product Packaging	350	70	1000	2500	1300	3300	24[b]	0.126	M
U_3O_8 Product Drying	1,480	70	1000	2500	1300	3300	24[b]	4.7	M
Vanadium Furnace	5,000	70	900	2600	1300	3300	24	12	E

[a]From SAR.

[b]Operates one day out of every two.

[c]The only road dust generated by plant operations is that caused by the tailings pond operator during his once per 2-hour inspection of the tailing disposal area.

(Dust from the tailings pond and the ore stockpiles have not been included. Emissions from the sources cannot be quantified because (1) no dust is generated during periods of low wind regime, and (2) during the infrequent periods of higher wind velocities, dust becomes airborne over the entire region, making accurate sampling of emissions impossible.)

Table 3.4. Typical Product Analyses[a]

Uranium Product (Yellowcake)			
	%		%
U_3O_8	95.22	Ca	0.05
V_2O_5	0.3	Na	0.25
PO_4	0.03	B	0.001
Cl^-	0.01	K	0.02
F	0.01	SiO_2	0.9
Mo	0.02	Ti	0.01
SO_4	0.7	Mg	0.01
Fe	0.09	Zn	0.1
As	0.01	CO_3	0.02

Vanadium Product	
	%
V_2O_5	98.5
Na_2O	0.5
Fe	0.35
SiO_2	0.6
As	0.02
PO_4	0.01
Mo	0.01

[a]From "Response to NRC Queries of October 28, 1976 for the Uranium Mill of Atlas Minerals Division of the Atlas Corporation at Moab, Utah," Atlas Minerals Division, December 9, 1976.

Table 3.5. Sources of Mill Liquid Waste[a]

Stream	Mill Section	MT/day Liquids	MT/day Solids	MT/day
Filter cake	Acid tailings wash	218	544	762
Raffinate	V_2O_5 SX	1090	-	1090
Filter cake	Alkaline tailings wash	218	523	741
Raffinate	Copper cementation	8	-	8
Decanted tailings[b] pond water	Mill recycle and repulp	1310	-	1310
	Total	2844	1067	3911

[a]From SAR, Figure 3.1-2.

[b]Decanted tailings pond water sent to the mill circuit and to tailings sumps and recycled back to the tailings pond. Net flow of liquid effluents to tailings pond = 2844 - 1310 = 1534 MT/day.

contents. Because the products recovered by the milling process represent a vary small fraction of the ore mass, the amount of solids in the tailings stream is approximately equal to the ore feed rate plus part of the reagents used in the process. The expected composition of the tailings pond liquids is given in Table 3.6, based on the analysis of a synthetic raffinate that reflects proposed modifications in the uranium milling processes.

Table 3.6. Expected Composition of Liquid in Tailings Pond[a]

Component	Concentration In Tailings Pond
Ra-226, μCi/ml	1×10^{-7}
Th (nat.), μCi/ml	0.05×10^{-6}
Cl, g/l	0.3
SO_4, g/l	100.0
As, g/l	0.007
TDS, g/l[b]	150.0
U_3O_8 g/l	0.002
V_2O_5, g/l	0.3

[a]From ER.

[b]Total dissolved solids.

3.2.3.4 Control of Non-Radioactive Mill Waste and Effluents

Gaseous and Particulate Effluents

Each major building within the mill has natural-draft and powered exhaust ventilators to control the level of fugitive dust in the work areas. The powered exhaust fans are mounted on the roofs, and the natural-draft ventilators are long, protected openings located at the crest of each building roof. Dust generated from ore crushing and movement is controlled by bag-type dust collectors at the crusher building, at the fine-ore storage feeders, and at the sample tower. A collection efficiency of 99% is reported for these collectors. Wetting agents are used to minimize excessive dusting when dry ores are being crushed. Similarly, ore grinding is conducted on a wet basis at ambient temperatures to eliminate significant emissions of dust or fumes. Airborne particulates from U_3O_8 product drying and packaging are controlled by the use of wet scrubbers with collection efficiencies of 99.18% and 99%, respectively. The vanadium fusion furnace employs a dry-type dust collector with a 98% efficiency.

The copper-leaching tanks and the copper cementation section are equipped with exhaust systems to dissipate evolved gases such as CO, CO_2, and SO_2. The acid-leaching system employs collectors and demisters to contain chemical emissions and to inhibit releases to the environment. Natural ventilation is used, where adequate, to provide dispersion of gases, e.g., in the release of trace hydrogen from the open EMF control tank.

Liquid and Solid Effluents

All liquid and solid effluents are impounded in the tailings pond, and are not permitted to be released from the mill facility. In addition to the tailings pond, other smaller ponds within the plant boundary are used (1) to contain the Colorado River water solids extracted by the water treatment system, and (2) to contain any large spills that may occur during the milling process.

Several design criteria are followed to ensure the integrity and stability of the tailings pond system. The ponded water is kept in a central location through the use of a centrally located pumping decant barge and by moving the position of the discharge point to the area where water is closest to the dike. To minimize the possibility of overflows and spills, the distance of the pond edge from the embankment is kept at no less than 150 feet (45 m) except for the west embankment, which is designed as a water-retention dike with appropriate drains and riprap protection for wave run-up. Accurate control of water level is achieved by the centrally located decant barge.

The new west embankment is designed with sufficient safety factors (1.6 to 2.2) to withstand existing and projected static loading conditions, a maximum anticipated earthquake loading of 5% gravity, and the possibility of embankment liquefaction. The exposed surfaces of the tailings embankment is covered with approximately one foot (30 cm) of "shale" material from adjacent hillsides to reduce wind and rain erosion of the slopes.

Past seepage from the tailings pond has been calculated at around 1.7 gpm (1×10^{-4} m^3/sec) per acre of pond surface. However, future seepage rates are expected to be lower because the rate of flow of water circulated to transport the tailings to the pond has been reduced from 1000 gpm to 200 gpm (6×10^{-2} to 1×10^{-2} m^3/sec), reducing the quantity of water flowing over the more permeable "beach" tailings. Also, sealing is postulated to have occurred due to mixing of the tailings from the acid- and alkaline-leach circuits resulting in the deposition of gypsum in the tailings pond. (Sec. 3.2.6.5 is a discussion of future seepage.)

Sanitary and Other Mill Waste Systems

Sanitary wastes are treated in a 3200-gallon (12,000-l) septic tank and leach-field system, both approved by the Utah State Board of Health. A commercial operator cleans out the system annually and trucks the residual sludge to the City of Moab Municipal Sewage Disposal Plant, which provides primary and secondary treatment, in accordance with Atlas' contract with the City of Moab.

Used lubricating oil and grease, amounting to about 500 gallons (1900-l) per month, is collected from all gear boxes, motorized vehicles, and lubrication points throughout the plant. The material is stored in a 4500-gallon (17,000-l) tank prior to shipment in 4000-gallon (15,000-l) lots to a Salt Lake City refinery for reprocessing.

Laboratory and other solid wastes exposed to radioactive contaminants will be collected and buried in the tailings pile.

3.2.4 Radioactive Wastes and Effluents

In the following sections those steps of the milling process that yield radioactive effluents are described and release rates are analyzed using available data from similar operating plants, staff site inspections, and measurements taken at similarly operating plants. The estimates of potential release are adjusted to a 20-year milling period to allow for future operations and to assure that all estimates are sufficiently conservative.

During previous operation, ore from the Atlas mill has contained an average of 0.25% U_3O_8 for the acid-processed ore and 0.20% U_3O_8 for the alkaline-processed ore. In the future, due to decreasing ore quality, the percentage of U_3O_8 will decrease, making the calculations in this section conservative as regards future operations. Under radioactive equilibrium conditions the ore contained an average of 700 pCi/g in the acid-process circuit and 560 pCi/g in the basic-process circuit of each of the radionuclides U-238, U-234, Th-230, Ra-226, and Pb-210.

The principal natural isotopes of uranium, U-238 and U-235, exhibit separate radioactive decay series. The concentration of U-235 in natural uranium is 0.72%, and the activity of this series in the ore is approximately 34 pCi/g. In the U-235 series, the only long-lived radionuclide is Pa-231, with a half-life of 3.43×10^4 years. The quantity of radioactivity released by the U-235 series is small in comparison with amounts from the U-238 series.

Figure 3.3 depicts the pathways for dispersion of radioactivity to air, surface water, and groundwater from mining and milling operations. Parameters used to derive the source terms for the radiological assessment, and the source terms themselves are listed in Appendix C-1, Tables C-1.1 and C-1.2. The sources of radioactive effluents from the mill are (1) the ore pad, crusher, and grinder, (2) the yellowcake dryer, and (3) the tailings.

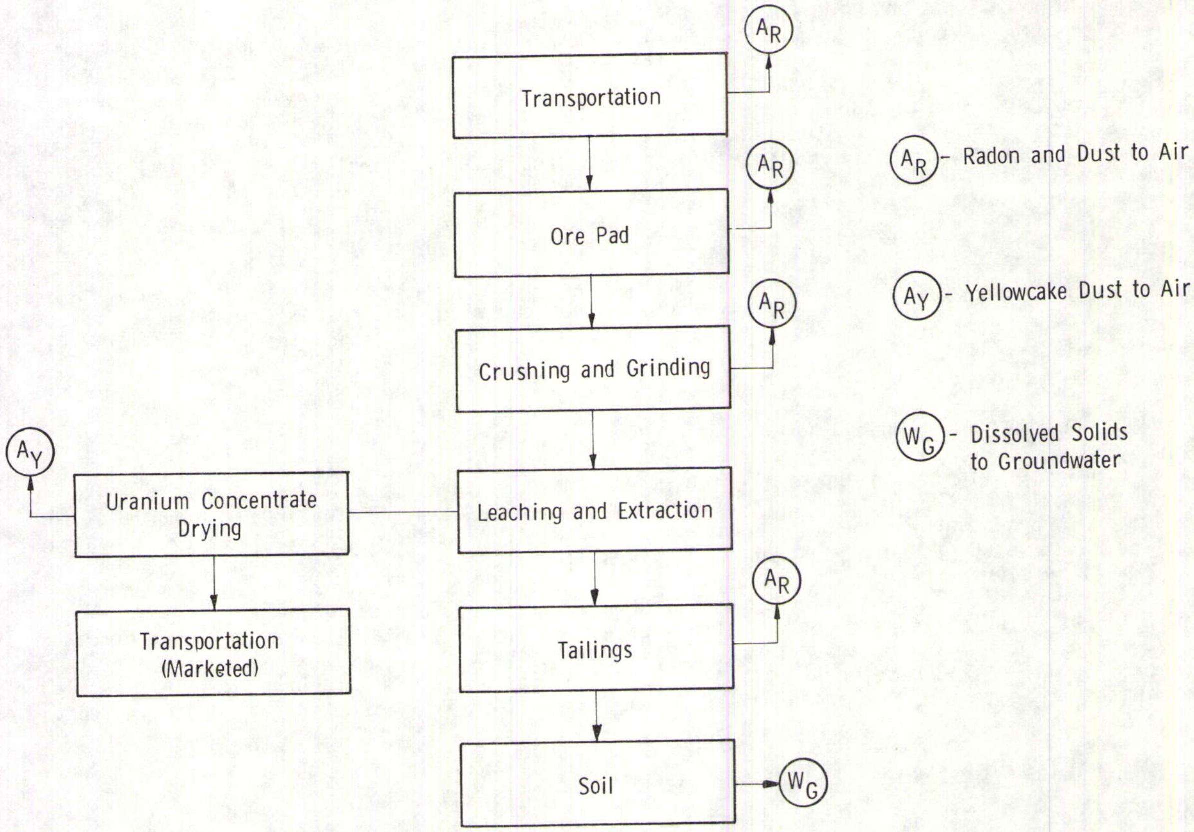


Fig. 3.3. Radionuclide Dispersion from Various Mill Operations to Air and Groundwater at the Atlas Mill.

Transportation of Ore to Mill

All of the ore will be shipped by truck. The main transportation route will be over a 200-mile segment of road, with the average haul distance being 80 miles. The concentration of radioactivity in the ore is low and ore spilled from truckbeds during transportation will be a small source of radiation. However, spillage from the trucks will comprise naturally occurring ore in large, moist aggregates which will not be readily suspended in air. The release of particulates to air will be low and will therefore contribute little to the overall emission of radioactivity from milling activities.

The applicant has extended his gamma radiation survey to ore haulage roads. The gamma dose rate measurements on the haulage roads were not significantly different than background gamma dose rate measurements in the area.

Ore Pad, Feed to Mill, and Ore Grinding

During normal operation, approximately 11,000 tons (10,000 MT) of ore are stored on the ore pad. The decay of Ra-226 in the ore produces Rn-222 (radon gas), which is released during the storage period. Storage for ten days results in the production of 85% of the secular equilibrium activity of Rn-222, 20% of which is available for release. Of this available 20%, partial release occurs on the ore pad while the remainder is released during subsequent ore feeding and crushing operations. The ore grinding process and the close interface maintained between liquid and solid phases during the leaching process will increase the radon release from the ore, but will simultaneously decrease the diffusion coefficient for radon. The staff estimates that the total radon released from the combined operations of ore storage, feeding, and grinding will be about 50 Ci/yr. This rate corresponds to normal release from 1×10^6 m^2 of natural terrain.

The average annual radionuclide release from ore storage, feeding, and grinding is computed to be less than 10 mCi each of Pb-210, Ra-226, Th-230, and U-238. Except for radon, most of this radioactivity will be associated with large-diameter dust particles that will not contribute to radioactivity outside the mill boundary (i.e., the unrestricted area). Stored ores are dehydrated during dry seasons, and if the surfaces are uncovered, these ores become potential sources of dust. However, because of the light wind regime in the area, fugitive dust generated by wind blowing across exposed ore is not expected to be a problem. Nevertheless, should windy conditions prevail, the ore pads will be sprinkled with water to minimize dusting (App. C, Table C-2.1).

Leaching

The leaching operation is a wet process that does not contribute to the emission of particulates. Because of the short transit time (less than one day) of the ore through the mill circuit, this process releases little radon to the environment.

Uranium Concentrate Drying and Packaging

After uranium precipitation and extraction, the uranium concentrate will be dried at 650° to 800°C in a multiple-hearth furnace. The dried product will be passed through a hammer mill for reduction to powder and/or granules approximately 0.25 inch in size. The product (yellowcake) will be about 96% U_3O_8 and contain about 3% of the Th-230, 1% of the Ra-226, and 1% of the Pb-210 originally in the ore. Emission of particulates to the air during uranium concentrate drying and packaging is controlled by wet scrubbers with efficiencies of 99.18% and 99%, respectively. The calculated concentrations of U_3O_8 in the drying and packaging scrubber discharges are 7.52 mg U_3O_8/m^3 and 0.8 mg U_3O_8/m^3, respectively. The product is packaged in 55-gallon (200 l) metal drums, each containing about 815 lb (370 kg) of the product. This packaging terminates the potential for uncontrolled release of radioactivity under normal operating conditions.

Radioactive Liquid Waste

The water for the milling operations will be drawn from the Colorado River at a rate of 121 gpm (241,000 m^3/yr) (SAR, Fig. 3.1-2, Material Balance). In contrast to past practice, all process wastewater will be discharged to the tailings pond; no direct discharge to the Colorado River is planned. Most of the uranium in the ore will be extracted in the process, and only six percent will be left in the tailings. Almost all the Ra-226 in the ore is retained in the tailings and will be carried by the discharge water to the tailings pond. About 450 mCi of Ra-226 will be sent to the tailings pond daily. Most of the radium will be insoluble, but approximately 135 μCi of the daily output will be soluble. Decant water from the tailings pond will be used for tailings transport. Since radium is largely held in an insoluble form in the tailings (only about 0.03% of the available radium is soluble in the tailings water), it will not be a significant source of surface water contamination.

Some seepage will occur from the tailings pond to the Colorado River. The maximum leakage rate is expected to be 50 μCi/day of Ra-226 at 80 gpm (300 l/min). The minimum flow rate of the Colorado River is expected to be 558 cfs. Based on the maximum leakage rate of Ra-226 and minimum flow rate of the river, the concentration of Ra-226 in the Colorado River will be 3.7×10^{-11} μCi/ml, which is below the MPC of 3×10^{-8} μCi/ml. It is expected that ion-exchange during seepage through the soil will further decrease the amount of Ra-226 lost to the Colorado River.

Tailings

The existing tailings dam embankment system covers a surface area of 115 acres with embankments up to 75-feet high, and contains 7 million tons of tailings. A minimum of 4 million tons (3.7 million MT) additional tailings are to be stored in the pond system (see Figs. 2.3 and 2.4). To accommodate the additional tailings, supplemental tailings dikes and a starter dike (along the presently open western portion of the pond) will be built. The dam structure, existing and planned, will conform to standards designated by the American National Standards Institute (ANSI N313-1974) on 20 June 1974, and cited in USAEC Regulatory Guide 3.23,[1] and to USNRC Reg. Guide 3.11.

The movement of groundwater under the tailings embankment section (and the mill site) is toward the Colorado River, with a gradient ranging from 15 to 30%. Across the river, the groundwater gradient from the city of Moab is also in the direction of the river. Therefore, there will be no transfer of groundwater north of the river to aquifers south of the river. Similarly, groundwater north of the mill, e.g., at Arches National Monument, would not be affected by any mill activities because of the direction of the groundwater gradient. The current estimate of the average seepage rate is 1.7 gpm/acre.

The tailings will be approximately 38% solids by weight and will contain approximately 513 pCi/g of solid Th-230, 540 pCi/g each of Ra-226 and Pb-210, and 27 pCi/g each of U-238 and U-234.

Air samples taken three feet above the surface of existing tailings piles at other mill sites have shown average airborne radon concentrations ranging from 3.5 to 15 pCi/l.[2] Similar concentrations are anticipated over the exposed surfaces (dry beaches) of the Atlas tailings piles. The amount of radon released from the soil is dependent on atmospheric conditions and on soil porosity, compaction, and moisture content. The maximum expected concentration will be 2×10^4 pCi/m^3 immediately over the tailings beaches.

During the active period of the mill, the radon release will be proportional to the relative areas of beach and liquid surfaces and to the depth of the tailings deposits. The radon release rate at the end of milling operations is estimated to be 5000 Ci/yr, based on 50% of the future total tailings retention area of 4.7×10^5 m^2 being covered with tailings solution. Since the diffusion length of radon through water is estimated to be only 1.5% of that through exposed tailings, the contribution from tailings covered by solution will be a small fraction of the total release rates.

Existing or anticipated tailings-management practices at the Atlas mill are subject to findings of the forthcoming NRC Generic Environmental Impact Statement on uranium milling and are subject to revision in accordance with the conclusion of the Final Generic Statement and related rule-making.

Transportation of Uranium Concentrate

The finished product is a mixture of essentially pure uranium oxide (U_3O_8) in the form of powder or granules less than 0.25 inch in diameter. It is packaged in 55-gallon (200-l) steel drums, which are sealed for shipment. Each drum weighs approximately 1000 lb (370 kg), and about 1200 drums will be shipped each year.

All shipments leaving the mill are made by truck.

There is no measurable release of radionuclides from the steel drums. However, about 2 mR/hr are produced at any edge of the truck bed.

3.2.5 Stabilization and Reclamation of the Mill Tailings Area

At the termination of milling activities, the applicant proposes to decontaminate the process equipment, selling it for reuse or as scrap metal. Mill structures will be put to other beneficial use for other activities if possible; if this is not possible, the structures will be removed, the foundations leveled and the entire mill site will be decontaminated to meet NRC requirements for release for unrestricted use.

Once the mill is decommissioned, the applicant will initiate a physical stabilization program to reduce potential wind and water erosion of the tailings-retention area. Reclamation will begin within two years following mill shutdown, allowing sufficient time for the surface water to evaporate from the tailings pond. The pile would then be shaped and contoured in such a manner that the slime tailings will be covered by at least five feet of non-slime (sand) tailings and that water runoff from the pile to the sides will be facilitated. The tailings would be capped with clay imported from offsite, then overlain by silty, fine sand obtained from the site and one foot of topsoil.

The clay cover as modified by staff calculations would be 1.75 foot thick over non-slime areas, and 2.0 feet thick in areas where five feet of non-slimes overlie the slimes. The silty, fine sands would be 4.0 feet thick in the non-slime areas and 4.3 feet thick in areas where five feet of non-slimes overlie the slimes. The area would then be revegetated with plant species appropriate to the area.

The estimated cost of the proposed stabilization plan is $3.3 million (1977 dollars). The application of the clay cap is intended to reduce infiltration of rainwater and leaching of the tailings following stabilization. (There would remain, however, the possibility that plant roots could penetrate to the tailings.) Wind and water erosion of the tailings would be controlled. There would also be a reduction in gamma radiation and radon release to specified levels while the appearance of the pile would be enhanced relative to its immediate surroundings. Any future recovery of minerals in the tailings would be relatively easy.

The staff also points out that information contained in the Generic Environmental Impact Statement on uranium milling, to be written by NRC, could modify or change the applicant's approach to stabilization. That statement, which will probably be completed in 1978, will contain the results of research presently in progress which is designed to assess the impacts of uranium mill tailings ponds and piles, and the means for mitigating any adverse impacts. The NRC licensing action on the Atlas mill will be subject to express conditions that approved waste-generating processes and mill tailings management practices be subject to revision in accordance with the conclusions of the Final Generic Statement and any related rule-making.

The applicant will be required to make surety arrangements to cover costs of reclaiming the tailings disposal area and of decommissioning the mill site.

At the present time, the NRC requires that, upon termination of uranium mill operating licenses, the land on which the tailings are stored shall be subject to the following specific restrictions:

1. The holder of the possessory interest will not permit exposure and release of tailings material to the surrounding area.

2. The holder of the possessory interest will prohibit the erection of any structures for occupancy by man or animals.

3. Subdivision of the covered surface will be prohibited.

4. No private roads, trails, or rights-of-way may be established across the covered surface.

The need for the construction of permanent fencing around the tailings pile area and the installation of permanent warning markers will be decided at the time of plant shutdown on the basis of results of ongoing reclamation and stabilization procedures. Discussions of alternative methods of managing tailings and of alternative reclamation objectives are presented in Section 10.

3.2.6 Mill Decommissioning

In addition to the stabilization plan, the applicant must submit a general plan for decommissioning of the processing facilities and ancillary structures. However, the NRC does not require submission of detailed decommission plans until near the end of the useful life of a project. Prior to termination of the license, the applicant will be required to submit more detailed information. This additional information will include data from radiation surveys taken at the site and plans for any mitigating measures that may be required as a result of the radiation surveys and NRC inspection. Before release of the premises or removal of the buildings and foundations, the licensee must demonstrate that levels of radioactive contamination are within limits prescribed by the NRC and the then-current regulations. Depending on the circumstances, the NRC may require that the applicant submit an environmental report on decommissioning operations prior to termination of the license. Additional details on decommissioning alternatives will be included in the NRC's Generic Environmental Statement on uranium milling.

References for Section 3

1. "Stabilization of Uranium - Thorium Milling Waste Retention Systems," Regulatory Guide 3.23, U. S. Atomic Energy Commission, Directorate of Regulatory Standards, Washington, D. C., November 1974.

2. "Evaluation of Radon-222 near Uranium Tailings Pile," joint report of the U. S. Dept. of Health, U. S. Atomic Energy Commission, Colorado State Health Agency, and Utah State Health Agency (available from Supt. Docs., U. S. Gov't Printing Office, Washington, D. C.), March 5, 1969.

4. ENVIRONMENTAL IMPACTS

4.1 AIR QUALITY

The principal impact on air quality of continued mill operations will be an increase in suspended particulate matter, principally fugitive dust removed from the tailings piles and carried by the prevailing winds. Because most fugitive dust becomes suspended during higher wind speeds, the staff selected slightly unstable conditions and 12 mph (20 km/hr) winds to be representative of upper-limit airflow. (These conditions occur infrequently in southeastern Utah.) Dust release under these conditions is anticipated to be 0.4 lb/hr-acre (0.45 kg/hr-ha).[1] According to calculations made by the staff, the average annual increase in concentration of suspended particulates from the wetted tailings will be 1 $\mu g/m^3$ at the Moab city limits. The applicable national standard is 75 $\mu g/m^3$ [40 CFR, Section 50.7(a)]; the present level is 25 $\mu g/m^3$. Additional sources of particulates are fugitive dust from the dust collectors, the packaging and drying operations, and the vanadium furnace. The average annual suspended particulate concentration from these additional sources is calculated by the staff to be 1 $\mu g/m^3$ at the Moab city limits, for a total additional load of 2 $\mu g/m^3$ of suspended particulate matter at the Moab city limits.

Additional possible sources of impact are gaseous effluents from plant operations. The maximum annual SO_2 concentration is calculated by the staff to be 0.1 $\mu g/m^3$ at the Moab city limits, whereas the applicable national standard is 80 $\mu g/m^3$ [40 CFR, Section 50.4(a)]. Other gaseous effluents from the milling operations could also be present, but are not expected to affect air quality because of the small outputs involved.

4.2 LAND USE

4.2.1 Land Resources

The 400-acre (160-ha) Atlas Minerals property has been altered in part since 1956 by the presence of the mill. About 200 acres (80 ha) of the original sagebrush-grassland have been disturbed. Continued operation of the Atlas mill would not require the disturbance of additional lands beyond the approximately 200 acres (80 ha) presently committed to the project. The area devoted to the mill itself would be reclaimed after operations cease, but the 115-acre tailings area, under present reclamation plans, must be considered unavailable for further productive use.

4.2.2 Historical and Archeological Resources

The continued operation of the mill does not affect any historical or archeological site listed in the National Register. Any archeological or historical remains located in the area where the mill is in operation have been by now highly disturbed or destroyed.

4.3 WATER

By mid 1977, all liquid wastes were impounded in the tailings pond, thus eliminating direct discharge of effluents into any surface waters. (For a discussion of seepage, see Sec. 3.2.6.5.) This plan is in compliance with a legal agreement between the Atlas Corporation and the U. S. Environmental Protection Agency by which the mill would adopt total containment by 1 July 1977.

Since direct discharge of effluents to the Colorado River has been eliminated, future changes in the quality of the groundwater and river water resulting from milling operations can be attributed to seepage from the tailings pond. The operation of the acid leach circuit is expected to increase the TDS of the tailings pond water to 150 g/l (ER), but the resulting deposition of gypsum in the tailings pond will reduce seepage (computed at 78 gpm or 5×10^{-3} m^3/sec for the old alkaline leach operations) by promoting sealing. Groundwater deposits at the site have moderately high salinity, ranging from 2000 to 12,500 mg/l (Suppl. I to ER, p. 24), and any increase in salinity due to seepage is expected to be small.

Calculated increases in TDS content of Colorado River water, based on the seepage rate of 78 gpm (5×10^{-3} m^3/sec), are 8.5 ppm and 46.6 ppm for the mean low river flow of 3066 cfs (87 m^3/sec) and an instantaneous low river flow of 558 cfs (16 m^3/sec), respectively. Under conditions of normal flow (7711 cfs or 218 m^3/sec), the added concentration will be 3.37 ppm (Ref. 2, response to Q. 15), which is considered insignificant. Perfect mixing between groundwater and river water is assumed because the groundwater will enter the river along several hundred feet of bank.

Concentrations of arsenic are expected to be negligible when the seepage mixes with the river water. However, arsenic levels in the groundwaters could exceed the Utah State Division of Health's mandatory limit of 0.05 mg/l. The applicant conducts frequent analyses of the arsenic concentrations in the tailings pond and in the monitor wells. Appropriate treatment of the pond liquid will be instituted if necessary.

4.3.1 Surface Water

Approximately 121 gpm (241,000 m^3/yr) of water is withdrawn from the Colorado River for makeup water use in the Atlas mill (SAR, Fig. 3.1-2). This is only about 0.0035% of the average river flow (7711 cfs or 218 m^3/sec) and about 0.05% of the minimum flow (558 cfs or 16 m^3/sec); thus, no impacts on surface water use are apparent or expected (see Fig. 4.1).

4.3.2 Groundwater

No groundwater is utilized for any mill operation; therefore, no adverse effect to groundwater use is expected. Also there is no adverse impact on groundwater quality due to seepage from the tailings pile (see Sec. 4.7.4.1, Water Pathway).

4.4 MINERAL RESOURCES

The only major economic mineral resources identified in the region of the Atlas mill are uranium, oil, and potash. All are being actively exploited. However, because these operations are not in the immediate vicinity, continued operation of the mill will have no adverse effect on their development.

4.5 SOILS

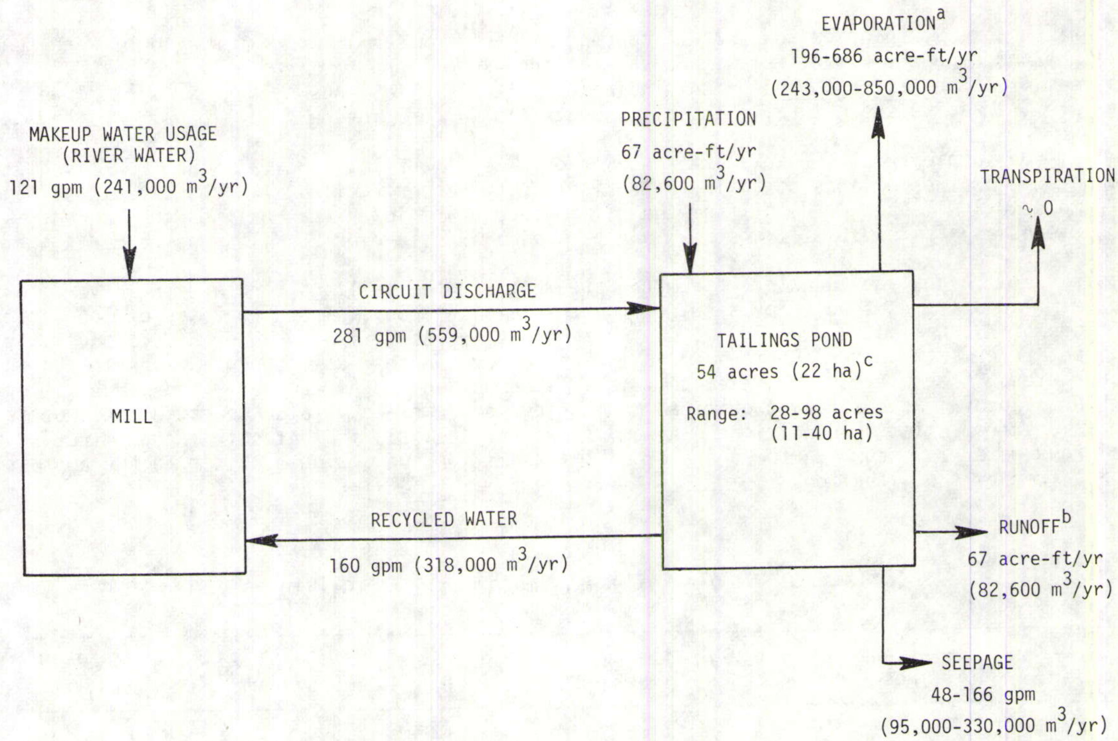
4.5.1 Physical Impacts

Earth moving associated with the initial construction of the mill buildings and associated facilities has probably destroyed any pre-construction soil profile. In the opinion of the staff, any such impact was inconsequential because: (1) the soils adjacent to the mill site (except toward the Colorado River) appear to be of recent colluvial (slope wash) origin and are apparently still accumulating (see Sec. 2.8), and (2) the soils of the mill site were probably members of the great group Torriorthents and had little or no development of pedogenic horizons (see Sec. 2.8.2). Construction activities and subsequent operational traffic have probably compacted the soil, but in the judgment of the staff, the impact of this compaction is minor because of the lack of pedogenic development and the likelihood of natural mitigating influences, such as the active accumulation of colluvium. The soil profile at the tailings pond site has been irretrievably buried under the tailings.

The acreages of soils affected are shown in Table 4.1. The magnitude of the impact is best assessed by restricting the analysis to the Moab and Spanish Valleys because adjacent plateau areas are covered with a very thin residual mantle that is not comparable to the deep alluvial and colluvial deposits in the valley (see Sec. 2.8.1). Similarly, the marshland and river have been excluded because of their dissimilarity to the remainder of the valley floor. As an indicator of the agricultural potential of these soils, cultivated soils comprise 1890 acres (765 ha) of the 6989 undeveloped acres (2828 ha) in the Moab and Spanish Valleys within ten miles (16 km) of the mill, or about 20% of the soils. By contrast, no soils derived from residual mantle within ten miles of the mill are cultivated. The staff does not find evidence that the operation of the mill has increased or will increase soil erosion at the mill site.

4.5.2 Nonradiological Chemical Impacts

Analysis of data from several years of chemical monitoring (SAR Sec. 2) reveals that the alluvial deposits along the Colorado River at Moab have natural chloride and sulfate concentrations which vary randomly from a few hundred ppm to over ten thousand ppm.



[a]Evaporation and seepage from the tailings pond will depend on the actual surface area of tailings solution exposed (the numbers quoted are based on a 28-acre pond).

[b]A portion of the tailings pond is not diked to divert runoff water, and it is estimated that the runoff area allowed to drain to the tailings pond is approximately equal to the pond itself.

[c]54 acres is the maximum recommended limit of the ponded water.

Fig. 4.1. Solution Balance for the Atlas Mill.

Table 4.1. Acreages of Soils Disturbed at the Atlas Mill Site

	Acres	Hectares	% of Valley[a]
Mill[b]	85	34.4	0.7
Tailings	115	46.6	1.0
Cultivated	1890	765.5	16.0
Total built up[c]	2140	866.7	18.1
Rangeland	8336	3376.1	64.2

[a]Within the ten miles of mill, excluding marshlands and the Colorado River.

[b]Includes associated facilities, except the tailings pond.

[c]Total disturbance due to buildings, roads, etc., in Moab and Spanish Valleys, including mill and tailings.

Comparison of TDS, chloride and sulfate concentrations from sample locations; (1) between the tailings pond and the river, (2) within the tailings sands, and (3) from a site about 0.6 mile upstream from the tailings pond do not indicate that either tailings seepage or wind blown tailings are increasing the natural chemical concentrations found in the area along the river.

Analysis of sample results (Table 4.2) conducted in September 1977 indicate that for five metals known to be in the tailings pond liquid in significant concentrations, the concentrations found in samples 0.1 mile downgradient from the tailings pond are lower than half of the concentrations found at a site 0.6 mile upstream and at a similar site over 25 miles upstream.

Samples will be analyzed quarterly from the area between the tailings pond and the river and from similar sites unaffected by seepage from the tailings pond. Trend analysis of the concentrations of K^+, Na^+, Cl^-, $SO_4^=$, NO_3^-, Cu, Fe, Mn, As, Se, as well as pH, TDS and conductivity will be performed to determine if seepage is increasing the chemical concentrations in the groundwater. Alert levels for this analysis will be subject to NRC approval and may be altered with NRC approval as sufficient chemical monitoring data are accumulated to establish expected variations from existing conditions. At any time that analysis indicates that contamination of the groundwater is occurring the operator will take mitigative action, subject to NRC approval, as required by the situation.

Table 4.2. Sample Analyses, September 1977 (all in ppm)[a]

Element	Atlas Tailings Pond	0.1 Mile Nearest Riverbank	0.6 Mile Upstream	Over 25 Miles Upstream
Al	1043	11.84	17.69	8.51
Cu	8.5	0.08	< 0.05	< 0.05
Fe	1178	14.26	24.3	5.71
Mn	73	1.82	2.44	2.40
Zn	13.64	0.065	0.451	0.063

[a]Argonne National Laboratory sample results.

4.6 BIOTA

4.6.1 Terrestrial

4.6.1.1 Construction Impacts

Virtually all of the present Atlas mill site appears to have been occupied by a desert grassland (probably galleta-three awn, see Sec. 2.9.1.1) prior to the construction of the mill (Ref. 2, Fig. 3 accompanying Query No. 8). The staff estimates that a total of 194 acres (78.6 ha) of grassland and six acres (2.4 ha) of riparian woodland have been disturbed (Table 4.3). This represents approximately 43% of the preexisting grassland and 1.4% of the preexisting woodland and marsh grasslands within 0.9 mile (1.5 km) of the present tailings pond. [This distance includes most of Moab Valley north of the Colorado River, most of Moab Marsh, and almost no area beyond Moab Valley.]

If the projected alternative evaporation pond is developed, an additional 20 acres (8.1 ha) of desert grassland will be disturbed, bringing the total disturbance to 47.5% of the preexisting grassland within 0.9 mile of the present tailings pond.

4.6.1.2 Impacts of Fugitive Dust

The composition of fugitive dust from the tailings pond has been different from that of natural dust, specifically in leachable salts (see Sec. 4.5). The impact of these salts is difficult to predict. The staff speculates that fugitive dust deposition has had no appreciable impact on the wetlands (riparian woodlands and marsh grasslands) because of the dilution of the salts by the relatively abundant water and removal of the salts by the relatively high volume of groundwater flow. In the drier areas (shadscale and desert grasslands), the result of dust deposition has probably been a shift toward badlands-like communities,[3] either due to simulated gypsiferous

Table 4.3. Vegetation Disturbed by Construction of Atlas Mill[a]

Vegetation Type	Mill[b]		Tailings Ponds		Alternative Tailings Pond		Total	
	acres	ha	acres	ha	acres	ha	acres	ha
Desert grassland	81.5	33.0	112.5	45.6	20.0	8.1	214	86.7
Riparian woodland	3.5	1.4	2.5	1.0	-	-	6	2.4
Total	85.0	34.4	115.0	46.6	20.0	8.1	300	89.1

[a]Staff estimates.

[b]Including associated facilities, except the tailings pond.

conditions resulting from the sulfates and/or increase in total soluble salts (cf. Ref. 3). This induced shift in biotic communities is analogous to allogenic natural successional change (change in an ecologic succession caused by changes in the external environment or habitat). This type of successional change could occur as quickly as about five years, or as slowly as about 50 years. Since the mill operator is committed to control of fugitive dust from the tailings area, no significant shift in biotic communities is predicted.

The major possible impacts on fauna resulting from fugitive dust are the potential bioaccumulation of heavy metals or trace elements to toxic concentrations. Of the known soluble salts in the fugitive dust (Table 4.2), the trace element most likely to bioaccumulate is arsenic. Plants apparently accumulate arsenic,[4] which, in turn, can build up in the tissues of animals by way of the food chain. Apparently, arsenic is not immobilized in the skeletal tissues of animals.[4]

However, because the applicant is committed to dust control (Sec. 10.3.2), the future impacts of this dust will be minimized.

4.6.2 Aquatic

As stated in Section 4.3.1, subsurface seepage from the tailings pond (at a rate of up to 80 gpm or 5×10^{-3} m^3/sec) may reach the river by natural groundwater movements. Although the tailings seepage will contain soluble salts, and could possibly contain toxic trace elements, the combined dilution of the seepage with groundwater and river water will reduce concentrations to at least 1/1000 of initial levels in the seepage. Staff calculations indicate that maximum concentration increases induced for all pertinent chemical parameters in the Colorado River at low river flow by tailings pond seepage will be in the range of $\sim$ 1% to 5%. These increases are within ambient variations. There should be no detectable effects on indigenous aquatic communities.

4.7 RADIOLOGICAL IMPACTS

The sources of radiological impact to the environment of the Atlas milling site are the natural radiation background of the area (Sec. 2.10) and the contribution of certain mill effluents. The exposed population comprises the workers at the site, the public coming within the vicinity of the mill (e.g., at Arches National Park and the Colorado River), and the public within a 50-mile (80-km) radius of the mill.

4.7.1 Preoperational Radiation Environment

The preoperational radiation environment at the Atlas site represented a combination of the natural radiation environment and radiation resulting from industrial operations. The natural radiation environment is a result of cosmic radiation, cosmogenic radioactivity, and terrestrial radioactivity (see Sec. 2.10). Radiation background at the Atlas site is not affected by other facilities in the area because of the remoteness of the location from other sources of radioactive materials such as the Rio Algom and Union Carbide mills, 25 and 45 miles (40 and 74 km), respectively, away.

The intensity of cosmic radiation is a function of altitude and geomagnetic latitude. In Utah, the dose equivalent due to cosmic radiation is about 65 mrem/yr[5-11] to the whole body. The dose equivalent from cosmogenic radioactivity, primarily from C-14, is about 1.0 mrem/yr[12-15] to the whole body.

Terrestrial radiation is mainly from the primordial radionuclides K-40, Rb-87, and the series originating in U-238, U-235, and Th-232. The concentration of these radionuclides in the soil is dependent on the epigenesis of the area.[16,17] The soil in the Atlas mill area is of the unconsolidated beach sands variety. For such soils, the concentrations of U-238, Th-232, Rb-87, and K-40 are, respectively, 1 pCi/g, 1 pCi/g, 0.7 pCi/g, and 8 pCi/gm.[12] At a height of 3.2 ft (1 m), the exposure rates due to these radionuclides are 14 mR/yr from U-238, 15 mR/yr from Th-232, 0.5 mR/yr from Rb-87, and 11.2 mR/yr from K-40.[12]

The applicant has taken measurements of the radionuclides content and radiation levels of the soil at 14 locations around the mill ranging to 8.5 air miles from the mill. Because the Atlas site is located at the northwestern edge of the Moab Valley, the measurement points that are most representative of the preoperational site conditions would be those farthest away, i.e., within the valley, to the southeast. At a point 8.5 miles southeast of the mill, the radiation dose equivalent rate was measured at 0.0035 mrem/hr. For the state of Utah, the whole body dose equivalent rate has been estimated to be 0.0046 mrem/hr,[11] equivalent to 40 mrem/yr.

The U-238 content of unconsolidated sands is estimated to be 1 pCi/g.[12] Assuming secular equilibrium among the daughters of U-238 yields a radon flux of 1.6 pCi/m^2-sec.[18] The annual quantity of radon released from the total area of the Atlas project (1.62×10^6 m^2) is thus about 82 Ci. The concentration of radon in air is a function of atmospheric conditions; the mean concentration is estimated to be in the range of 500 to 1000 pCi/m^3. With normal background conditions, a continuous exposure would deliver a dose of 500 to 1000 mrem/yr[19] to the segmented bronchi.

The annual average concentration (25 μg/m^3) of particulates in Utah air will contain 2.5×10^{-5} pCi/m^3 of Ra-226, 1.75×10^{-5} pCi/m^3 of Th-232, and 2.5×10^{-5} pCi/m^3 of Th-230. The dose from these particulates to the lung, under normal conditions, would be about 2 mrem/yr, and the dose to the bone would be less than 1 mrem/yr.

The medical whole-body dose for Utah is estimated to be 75 mrem/yr[20] per person. The U. S. average for 1980 is estimated to be 86 mrem/yr[11] per person. For the Atlas area, the radiation dose rate from the preoperational environment is estimated to be 180 mrem/yr per person.

4.7.2 Radiological Impacts from Routine Operations

Radiation doses were estimated for both individuals and the general population living near the Atlas mill. These estimates were calculated on the basis of recommendations of the International Commission on Radiological Protection (ICRPII)[21] and the report of the Task Group on Lung Dynamics for Committee II of ICRP.[22] The following information was used in the dose calculations:

- Estimates of predicted radioactive releases presented in Section 3.2.4,
- Site meteorological and hydrological considerations discussed in Sections 2.1 and 2.6, and
- Land-use information discussed in Section 2.5.

These calculations show that the radioactive effluents released to the environment from the Atlas mill will result in only small radiation doses to the public.

4.7.3 Exposure Pathways

The environmental exposure pathways that were considered in estimating the potential radiation dose commitments to man are shown in Figure 4.2. The estimates of dose commitments to man were made for radioactive effluent discharges to the environment using actual locations and characteristics of the mill site environs, and the actual pathways by which members of the public can be exposed to the discharges. Included in the staff's analysis are dose-commitment evaluations of three effluent categories: 1) pathways associated with particulate releases to the atmosphere, 2) pathways associated with gaseous releases to the atmosphere, and 3) pathways associated with seepage of liquid effluents to groundwater. For the Atlas mill, the pathways of importance for producing the most significant dose commitments to individuals and populations are: 1) inhalation of radon and daughter products, and 2) inhalation of radioactive dust particles. Other less significant exposure pathways are the ingestion of radionuclides in beef, and external radiation exposure. All other exposure pathways contributed much less significant dose commitments.

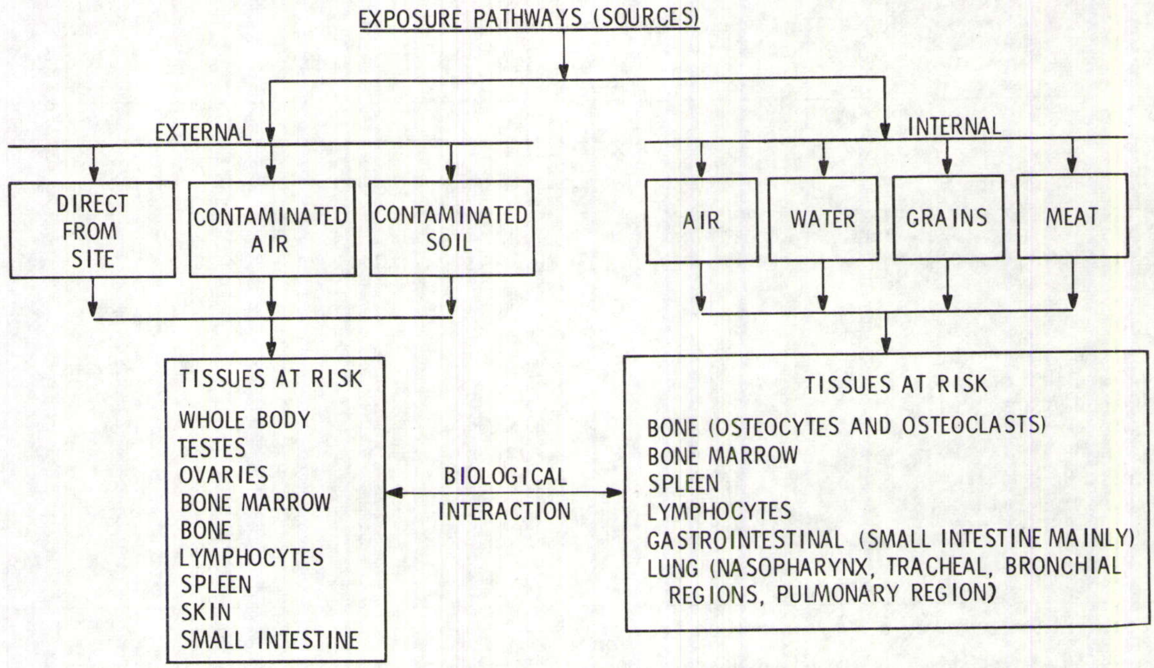


Fig. 4.2. Exposure Pathways.

4.7.4 Radiation Dose Commitments to Individuals

A summary of the predicted doses to individuals at selected offsite locations where doses are calculated to be largest are listed in Table 4.4. Estimates are presented for the significant exposure pathways discussed in Section 4.7.3.

The highest doses received by individuals from the operations of the Atlas mill are expected to occur at the Tex's Tour Center, a recreational boat landing several hundred meters east of the mill site boundary, and at residences at the Arches National Park headquarters located 2.4 km northwest of the mill.

The predicted annual dose commitments to an individual using Tex's Tour Center as a full-time residence are 74 mrem/yr to the lungs, 30 mrem/yr to bone, and 188 mrem/yr to the bronchial epithelium. The predicted annual dose commitments to a permanent resident at Arches National Park headquarters are 15 mrem/yr to the lungs, 6 mrem/yr to bone, and 74 mrem/yr to the bronchial epithelium. At locations farther from the mill, individuals will receive lower doses from mill operations than estimated for these two areas.

A brief discussion of the various pathways for radiation exposure to individuals near the mill are present in the following sections.

4.7.4.1 Internal Exposures

Air Pathway

The concentrations of uranium, Th-230, Ra-226, Pb-210, and Rn-222 in air resulting from airborne releases from the Atlas mill are presented as a function of distance from the site in Appendix C, Part C-3. The annual radiation dose commitments to individuals at offsite locations from inhalation of these radionuclides are given in Appendix C, Part C-4. These doses were calculated using dispersion factors given in Appendix C, Part C-2, and the ICRP Task Group lung model.[22]

Calculation of the dispersion of airborne pollutants in Moab Valley is difficult, and the accuracy of the results is as yet unproven. The topographical barriers to pollutant dilution make the application of conventional dispersion models questionable.[23] The models used by the staff are those proposed by Slade[24] and the American Society of Mechanical Engineers,[25] and are the best models available to the staff; the results obtained are probably conservative. The onsite meteorological data used are the best available, as are staff estimates of pollutant releases.

Table 4.4. Annual Dose Commitments[a] to Individuals from Radioactive Releases from the Atlas Mill

Location	Exposure Pathway	Dose, mrem/yr Whole Body	Lung	Bone	Bronchial Epithelium
Nearest Permanent Resident	Inhalation[b]	1.2	73.6	28.4	18.8[c]
Tex's Tour Center,	External	0.8	0.8	1.2	--
0.8 km E of mill					
	Total	2.0	74.4	29.6	18.8
Permanent Resident	Inhalation	0.3	14.5	5.8	74
Arches National Park	External	0.2	0.1	0.2	
Headquarters, 2.4 km					
NW of mill	Total	0.5	14.6	6.0	74
Nearest Resident with	Inhalation	0.06	3.0	1.1	26.3
Ingestion Pathway,	Ingestion	0.4	0.4	5.0	--
2.7 km SE of mill	External	0.03	0.02	0.04	--
	Total	0.5	3.4	6.1	26.3

[a]Doses integrated over a 50-year period from one year of inhalation or ingestion.

[b]Doses to whole body, lung, and bone are those resulting from inhalation of particulates of U-238, U-234, Th-230, Ra-226, and Pb-210. The doses to the bronchial epithelium are those resulting from inhalation of radon daughters.

[c]Dose calculations are based on two virtual point sources: 1) the ore pad, 0.8 km W of Tex's Tour Center, and 2) the tailings pond, 2.7 km SW of it.

Until new models are proven to be capable of accurately predicting pollutant concentrations in terrain such as that around the Atlas site, models such as those now used by the staff must be employed.

This analysis shows that the inhalation of radon daughter products and radioactive particulates of uranium and thorium represents the major sources of radiation exposure to individuals from releases from the Atlas mill.

Water Pathway

Future milling operations will not discharge any radioactive liquid waste directly into the Colorado River. And because other potential sources of river-water contamination (seepage and airborne particulates) will be very small, no significant radiation exposure will result from surface water pathways.

Internal radiation exposure can also potentially occur from the contamination of drinking water with radionuclides released during plant operation. Radionuclides can potentially enter well waters by seepage from the tailings pond to groundwater aquifers. However, this contamination route is very unlikely because the groundwater gradients in the Atlas area all drain toward the Colorado River (see Sec. 3.2.6.6); therefore, no significant radiation exposure is expected to occur from groundwater pathways.

Food Pathway

The main radiation exposure pathway from food for individuals near the Atlas site is their consumption of meat. The local meat diet is principally beef, and to a much lesser extent mutton, deer, and antelope. Beef and breeding stock cattle are grazed on a pasture approximately 2 to 3 km (1.5 to 2 miles) southeast of the mill. The beef cattle are usually sold as calves for further feeding and eventual slaughter. To estimate the radiation exposure to an individual from consumption of beef raised on this site, it was conservatively assumed that the individual raising the cattle consumes 90 kg/yr (200 lb/yr) of this beef. This would result in an annual dose commitment of 5 mrem/yr to bone and 0.4 mrem/yr to the whole-body. (See also App. C-5.)

4.7.4.2 External Exposure

The concentration of radioactivity deposited on the ground was calculated on the basis of parameters provided in Appendix C, Part C-3. Both gamma and beta radiation could result in external exposure; the beta radiation dose is usually deposited in the skin or adjacent superficial tissues, whereas gamma radiation is more penetrating and a portion of the radiation dose is deposited in internal organs. As seen in Table 4.4, external gamma radiation is not a major exposure pathway to individuals living near the Atlas site.

4.7.5 Radiation Dose Commitments to Populations

The estimated annual whole-body and organ-specific dose commitments to the population of Moab, Utah, are presented in Table 4.5. Natural background doses are also presented for comparison. These dose estimates were based on projected population in the year 1990. The population dose commitments due to normal operations of the Atlas mill represent only very small increases in the population radiation dose rates from background radiation sources.

Table 4.5. Annual Population Dose Commitments to Population of Town of Moab in the Year 1990 (man-rem)

Receptor Organ	Mill Effluents	Natural Background
Whole body	0.2	750
Lung	9	1350
Bone	3	900
Bronchial epithelium	140	7500

4.7.6 Evaluation of Radiological Impacts on the Public

The predicted annual individual dose commitments (Table 4.4) resulting from the normal operations of the Atlas mill are only a small fraction of the present NRC dose limits for members of the public outside of restricted areas as specified in 10 CFR Part 20, Standards for Protection Against Radiation. Table 4.6 presents a comparison of the predicted annual dose commitments to individuals from operations of the Atlas mill with radiation protection standards for individual members of the public.

Although the mill is presently in compliance with the existing NRC exposure standards, the predicted doses to the lung and bone of the maximally exposed individuals either exceed or represent a substantial fraction of the Environmental Protection Agency's (EPA) Radiation Protection Standard for Normal Operations of the Uranium Fuel Cycle (40 CFR 190) which is to become effective for uranium mills in December of 1980.

Due to uncertainties resulting from the difficulties in calculating the dispersion of airborne pollutants in the Moab Valley (see Sec. 4.7.4.1), additional measurement data will be required in order to adequately assess whether the Atlas mill will be in compliance with the EPA Standard when it becomes effective. In order to provide data that can be used in determining compliance with the applicable standards, the mill operator will be required to conduct the expanded environmental monitoring program shown in Table 6.4.

If the measurement data from these programs do not provide a reasonable assurance that the mill will be in compliance with the EPA Standard, the operator will be required by NRC to provide additional effluent or land control to assure compliance with the standards. A specific license condition will be utilized to insure that the operator meets these requirements.

The population dose commitments (Table 4.5) resulting from the Atlas mill are only small fractions of the dose received from natural background radiation. They are also small compared to the medical and dental X-ray exposures given for diagnostic purposes.

Table 4.6. Comparison of Annual Dose Commitments to Individuals with Radiation Protection Standards

Receptor Organ	Estimated Annual Dose Commitments, mrem/yr	Radiation Protection Standard, mrem/yr	Fraction of Standard
PRESENT NRC REGULATION (10 CFR 20)			
Whole Body	2.0	500	0.004
Lung	74	1500	0.05
Bone	30	3000	0.01
Bronchial epithelium	0.032 (CWLM)[a]	1.2 (CWLM)[a]	0.03
FUTURE EPA STANDARD (40 CFR 190)			
Whole Body	2.0	25	0.08
Lung	74	25	3
Bone	30	25	1.2
Bronchial epithelium	0.032 (CWLM)[a]	NA[b]	NA[b]

[a]Radiation standards for exposures to Rn-222 and daughter products are expressed in Working Level (WL). WL means the amount of any combination of short-lived radioactive decay products of Rn-222 in one liter of air that will release 1.3×10^5 mega electron volts of alpha particle energy during their radioactive decay to Pb-210 (radium D). Cumulative Working Level Months (CWLM) is the term used to express the total accumulated exposure to radon daughter products in air.

[b]Not applicable, since 40 CFR 190 does not include doses from Rn-222 daughters.

4.7.7 Occupational Dose

Estimated doses received by mill workers are based on air-sample data (from February 1976 to February 1977) and dosimetry records (for the last quarter of 1976) supplied by the applicant. The air-sample data includes air concentration measurements at 21 locations throughout the mill and five breathing zones. In all cases the measured concentrations were below the maximum permissible concentration for occupational exposure.

The dosimetry data showed that the highest whole-body quarterly dose was 510 mrem (17% of dose limit) from X and gamma radiation, with 230 mrem being the highest single monthly dose. For non-penetrating radiation, the highest quarterly and monthly dose was 900 mrem (12% of quarterly dose limit for skin).

On the basis of the data available, it is estimated that the typical occupational dose in the Atlas mill does not exceed 25% of the recommended limit.

4.7.8. Radiological Impact on Biota other than Man

Although no guidelines concerning acceptable limits of radiation exposure have been established for the protection of species other than man, it is generally agreed that the limits for humans are also conservative for other species.[26-33] Doses to terrestrial biota, such as birds and mammals, due to gaseous effluents are expected to be similar to those calculated for man, and arise from the same dispersion pathways and considerations. Only one federally listed species, the prairie falcon (*Falco mexicanus*), which is classified as threatened, is reported as "an uncommon permanent resident in Arches National Park." Based on the applicant's commitment to the control of fugitive dust (ER, Suppl., "Tailings Management and Reclamation Alternatives Study") no adverse radiological impact is anticipated for the prairie falcon or for other resident animals.

Concentration of the radionuclides introduced by surface deposition in the Colorado River is very small. Exposure to aquatic organisms results from the water-soluble fraction of U-238 and its daughters. Aquatic organisms concentrate a number of elements that can be present in the aquatic environment. Accumulation coefficient values for several organisms are provided in the references.[21-23,26-30] The applicant's commitment to fugitive dust control will further reduce the rate of radionuclide deposition into the Colorado River, so even smaller concentrations in the river are expected.

4.8 SOCIOECONOMIC IMPACTS

Using data presented in Section 2.4, the staff has analyzed current and future impacts of the Atlas mill on the surrounding community.

4.8.1 Demography and Settlement Pattern

Because the mill has already expanded to meet future production needs, it can be expected that the number of employees will remain somewhat constant in the near future. Although the opening of the mill originally brought many people into the area, current and future operation will have no direct effect upon the population of Moab. Approximately 80% of the mill work force reside in Moab, and it can be expected that this residency pattern will continue.

Indirectly, the mill may cause some population increases. New mines may be opened within the county in the future because of the presence of the mill. Miners who may migrate into the county will require housing and services. The staff projects that the number of future in-migrants will be minimal and can be easily absorbed by the community.

Transient Population

Although many tourists pass within a ten-mile (16-km) radius of the Atlas mill (see Sec. 2.4.3), few people remain in the area for any extended amount of time. Visitors rarely remain beyond the time they allot for sightseeing. Despite the high turnover rate of visitors to the area, and the fact that the mill and tailings pond can be clearly seen by the tourists when ascending into Arches National Park, the contact of tourists with the mill is minimal.

4.8.2 Social Organization

No readily apparent adverse social impacts were identified by the staff. The State Social Service Agency reported to staff during site visitation that there were no problems unique to or associated with the mill's employees or their children. Discussions with local officials revealed that trucks handling ore and yellowcake had no unusual impact on traffic and accident frequencies and distribution.

Education

Currently, 158 children are enrolled in the Grand County School District whose parents are employed at the Atlas mill or in related mining operations.[34] The number whose parents are employed in dependent industries (i.e., other mines and trucking companies) cannot be determined, and will be assumed by the staff to be no greater than those whose parents are employed at the mill.

The school system is presently educating these children with minimal stress on the school facilities. The staff can find no adverse impact on the school district at present, nor predict any in the near future, that may be caused by the mill operation.

Health Facilities

Because no major increase in the mill work force is anticipated, no additional impacts on the region's health facilities are expected to occur as a result of mill operation.

4.8.3 Political Organization

Political impacts of the Atlas mill operation on the county and Moab are expected to have already occurred due to the length of time the mill has been operating.

4.8.4 Economic Organization

The mill has become an integral part of the economic structure of the area. It is the largest industrial employer in the county, employing five percent of the county's work force, and has created secondary employment, including mining and trucking operations.

By November 1976, approximately $7.3 million had been spent on plant construction, with another $2 million expected to be spent upon completion (Ref. 2, response to Q. 39). Atlas Minerals' property taxes for 1976 totaled $214,531.99 (Ref. 2, response to Q. 42). State and local sales taxes paid by the mill totaled $116,288.44 for the fiscal year ending 30 June 1976 (Ref. 2, response to Q. 43). The revenue generated by the mill has a large impact upon the city and county.

Employment*

As of 15 October 1976, the mill had 161 employees, with a monthly payroll of approximately $160,000 (Ref. 2, response to Q. 33). The average mill worker's income is approximately $10,000.

From employment records at the mill, the applicant selected and recorded certain characteristics by random sampling** to obtain a general socioeconomic profile of mill personnel for staff analysis (Ref. 2, response to Q. 33). These data show that eight of the 41 employees sampled (19.5%) lived outside of Moab. This figure is slightly lower than the ratio of all people living in the county to those living in Moab (see Table 2.3), and can be accounted for by the proximity of the mill to Moab. The average employee's age is 35; 85% are married, and the average number of children for those who have children is 1.94. Only 17% of the employees are female, and their jobs were scattered among the laboratory, clerical, and office positions.

Transportation

On the basis of traffic flow tabulations taken north of the mill, where a survey point is located, traffic to and from the Atlas mill comprises approximately 16% of total traffic in the area as seen in the following tabulation:

	Total Traffic	Atlas Mill	%
Utah and out-of-state passenger cars	900	160	18
Heavy trucks	295	90	31
Light trucks	405	5	1
Total	1600	255	16

4.8.5 Conclusion

The mill has provided several kinds of economic benefits to the county and to the city of Moab and may have influenced the establishment of some aspects of county and municipal goals. Mill workers moving to Moab have contributed to a general trend in population increase which may have increased stress in some social services; however, significant social problems in this city are not apparent.

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**A 25% random sample, or sampling of every fourth employee's records.

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5. ENVIRONMENTAL EFFECTS OF ACCIDENTS

The occurrence of accidents related to operation of the Atlas mill will be minimized through the proper design, manufacture, and operation of process components, and a quality assurance program designed to establish and maintain safe operations. In accordance with the procedures set forth in the appropriate regulations, Atlas Minerals Division has submitted applications containing descriptions of the facility design, the organization of the operation, and the quality assurance program. These documents, together with the environmental report and supplements, have been reviewed by various agencies to assure that there is a basis for safe operations at the site. Moreover, those agencies will maintain surveillance over the plant and its individual safety systems by conducting periodic inspections of the facility and its records, and by requiring reports of effluent releases and deviations from normal operations.

Notwithstanding the above safeguards, accidents involving the release of radioactive materials or harmful chemicals have occurred in operations similar to those conducted by the applicant. Therefore, in this assessment, accidents which might occur during milling operations have been postulated and their potential environmental impacts evaluated. Section 5.1 deals with postulated accidents involving radioactivity; Section 5.2 with those not involving radioactivity, and Section 5.3 with transportation accidents involving both radioactive and non-radioactive materials. The probabilities of occurrence and the nominal consequences are assessed, using best available estimates of probabilities and realistic assumptions regarding release and transport of radioactive materials. In cases of doubt, or where information adequate for a realistic evaluation was unavailable, conservative assumptions were used to compute environmental impacts. Thus, the actual environmental effects of the postulated accidents would be, in some cases, less than the effects predicted by this assessment.

5.1 MILL ACCIDENTS INVOLVING RADIOACTIVITY

The specific activities of the radioactive materials handled at the mill are extremely low: $\sim 10^{-9}$ Ci/g for the ore and tailings and $\sim 10^{-6}$ Ci/g for the refined yellowcake product.* The quantities of materials handled, on the other hand, are relatively large: $\sim$840 MT of yellowcake per year (for expanded operations), representing $\sim$520 Ci of radioactivity. These very low specific activities require the release of exceedingly large quantities of material to be of concern; driving forces for such releases are generally lacking at the Atlas mill.

Guidelines have not been published for the consideration of accidents at uranium mills. Therefore, the postulated plant accidents involving radioactivity are considered here in the following three categories:

1. Trivial incidents, i.e., those not resulting in a release to the environment,

2. Small releases to the environment (relative to the annual release from normal operations), and

3. Large releases to the environment (relative to the annual release from normal operations).

Trivial incidents include spills, ruptures in tanks or plant piping containing solutions or slurries, and rupture of a tailings disposal system pipe in which the tailings slurry is released into the tailings pond. Small releases include failure of the air cleaning system serving the concentrate drying and packaging area, a fire or explosion in the solvent extraction circuit, and a gas explosion in the yellowcake dryer. Large releases include a major tornado strike and releases to the watercourse from the tailings pond.

For most of the postulated cases resulting in a release to the environment the analysis gives the estimated magnitude of the release, the corresponding maximum individual dose at various distances from the mill, and the estimated annual likelihood of occurrence. The latter estimates

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*In contrast to the relatively high specific activities of a number of prominent radionuclides, i.e., $\sim 10^{-1}$ Ci/g for Pu-239 and $\sim 10^{-3}$ Ci/g for Co-60.

are based on a diversity of sources, including incidents on record, chemical industry statistics, and failure prediction methodologies. Data and models for the behavior of radiation in accident situations were taken from NRC Regulatory Guides[1] and from the International Commission on Radiological Protection[2] updated by dose conversion data published by the U. S. Environmental Protection Agency.[3]

During the three decades of nuclear facility operation, the frequency and severity of accidents have been markedly lower than in related industrial operations. The experience gained from the few accidents that have occurred has resulted in improved engineering safety features and operating procedures, and the probability that similar accidents might occur in the future is very low. Based on analysis, it is believed that even if major accidents did occur, there would probably not be a significant release of contamination offsite, and radiological exposures would be too small to cause any observable effect on the environment or any deleterious effect on the health of the human population.

5.1.1 Trivial Incidents

The following accidents, due to human or equipment failure, would not result in the release of radioactive materials to the environment.

5.1.1.1 Leaks or Rupture in Tanks or Piping

Uranium-bearing slurries and solutions will be contained in several tanks comprising the leach, washing, precipitation and filtration, and solvent extraction stages of the mill circuit. Human error during the filling or emptying of tanks, or the failure of valves or piping in the circuit, would result in spills which might be expected to occur several times annually during operations. Large spills from tank failures or uncorrected human error might involve the release of several hundred pounds of uranium in the liquid phase to the room. However, the entire contents of the tanks would be contained within the building sumps and any overflow beyond the building would be contained by concrete spillways and directed to an emergency holding pond. Therefore, a rupture of a process tank would not reach the environment.

5.1.1.2 Rupture of a Pipe in the Tailings Distribution System

At the design milling rate of approximately 1176 tons (1067 MT) of ore per day, roughly 45 MT of solids and 3.17×10^4 gallons (1.2×10^5 l) of solution (approximately 45% of which is recycled to the mill for process use) are transported to the tailings pond each hour through the tailings disposal system piping. Ruptures in the feed or decant lines would be expected to occur. The feed line parallels the tailings pond for most of its length; thus, any slurry released from the system would flow toward the tailings pond, where it would be contained along with existing tailings material. A rupture in the decant line or in the portion of the feed line between the mill and the tailings pond could result in a release to the river. (This case is considered in Section 5.1.3.2.)

5.1.2 Small Releases

The following accidents, due to human or equipment failure, would release small quantities of radioactive materials to the environment. The estimated releases, however, are expected to be small in comparison with the annual release from normal operations.

5.1.2.1 Failure in the Air Cleaning System Serving the Yellowcake Drying Area

The off-gases from the yellowcake dryer, containing entrained solid particles of uranium oxide, pass through a wet scrubber before they are discharged to the environment through a 6.4-foot (2-m) stack.

According to the applicant, measurements taken over three years of operation indicate an average release of approximately 0.9 lb/day (0.45 kg/day) of U_3O_8 during operation of the dryer (about one-third of mill operation time). Sampling conducted by the applicant shows the scrubber to be 99.18% efficient. Thus, should the scrubber fail completely during operations, the release rate of uranium to the atmosphere would be roughly 4.4 lb/hr (2.0 kg/hr).

The staff was informed during a site visit that, although stack monitoring for uranium will only be performed monthly, the circuit will be checked every hour as a part of the formal plant procedures. (In this regard, the staff recommends that the applicant maintain a record of such periodic inspections at least once per shift.) A drop in pressure would indicate loss of water flow to the scrubber, in which case operations would be terminated until the scrubber was repaired. If the failure occurred during daylight hours, the plume would be visible to an observer. Moreover, a drop in water pressure would induce a high-temperature trip which would shut down the system.

For the current analysis, it is assumed that the scrubber fails catastrophically during the night shift and that the pressure goes unchecked for the entire shift. This would result in the release to the environment of approximately 34.6 lb (15.7 kg) of insoluble uranium, assumed to be in the respirable size range. Figure 5.1 plots the 50-year dose commitments to the lungs* of individuals at various distances from the mill at this level of release.

Although quantitative data are unavailable, catastrophic (total) scrubber failure is highly unlikely. Progressive failure, in which case the plugging of vents causes back pressure, is readily detectable during operational checks, and produces inefficiencies rather than massive failure.

5.1.2.2 Fire or Explosion in the Solvent Extraction Circuit

The solvent extraction circuit, to be located in a separate, unenclosed area near the concentrator building, may contain as much as 12,500 lb (5700 kg) of yellowcake. It will be provided with a redundant, manually operated foam and automatic water spray system equipped with a thermal sensor. Moreover, an emergency dumping system will rapidly drain all solvent from the system if overheating occurs.

In the event of a major fire, it is conservatively assumed from previous estimates[4,5] relating to both uranium and plutonium solutions that as much as 1% of the uranium would be dispersed.** This would result in the ultimate release to the environment of approximately 125 lb (57 kg) of soluble uranium. Figure 5.2 shows the 50-year dose commitment to bone at various distances from the mill at this level of release.

From chemical industry data, the probability of a major fire per plant-year is estimated to be 4×10^{-4}.[6] However, at least two major solvent extraction circuit fires are documented in the literature, one of which destroyed the original solvent extraction circuit at the Atlas mill in 1968.[6] There have been approximately 540 plant-years of mill operation in the U. S.--equivalent to roughly 320 plant-years handling 390,000 MT ore/yr. Thus, judging from historical incidents, the likelihood of a major solvent extraction fire is in the range of 4 to 6×10^{-3} per plant-year. Using these two estimates to bracket the probability, the likelihood of a major solvent extraction fire at the Atlas mill is assumed to fall in the range of 4×10^{-4} to 6×10^{-3} per year.

5.1.2.3 Gas Explosion in the Yellowcake Drying Operation

A natural gas-fired furnace will be used to remove the water from the precipitated yellowcake following a two-stage filtration operation. The furnace consists of six hearths enclosed in a 5.9-foot (1.8-m) diameter cylinder. The inventory of yellowcake in the dryer will be approximately 4630 lb (2100 kg). The dryer off-gas, as discussed earlier, will be ventilated through a wet scrubber. An explosion in the dryer or the natural gas piping, however, could blow off the duct work associated with the ventilation system and disperse yellowcake into the room. The possibility of an explosion is mitigated by a Factory Mutual cock and pressure gauge installed on each of the six burners in the dryer.

The consequences of explosion accidents are limited by the concentration of heavy material that can be maintained in the air (estimated at approximately 100 mg/m^3).[6] Then, for a room volume on the order of $\sim 4 \times 10^3$ m^3, an estimated 14 ounces (400 g) of uranium would be released to the room air. Conservatively assuming that all of the uranium would be swept out into the environment when the room is ventilated, and that 100% of the insoluble particles are in the respirable size range, the 50-year dose commitments to the lungs of individuals at various distances from the mill are as plotted in Figure 5.3.

Quantitative data have not been found on natural gas furnace explosions. Failure rates have been evaluated for piping used in the transmission of natural gas and converted to equivalent failure rates per plant year,[7] indicating approximately 5×10^{-3} failures per plant-year. This is likely to constitute an upper limit of the likelihood of a gas explosion because it is based

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*Figures 5.1 through 5.7 show 50-year dose commitments to the critical organ, i.e., the organ receiving the maximum dose for a type of release.

**It is estimated that a smaller fraction of the uranium inventory would be released to the room, and subsequently to the environment, in the event of an explosion.

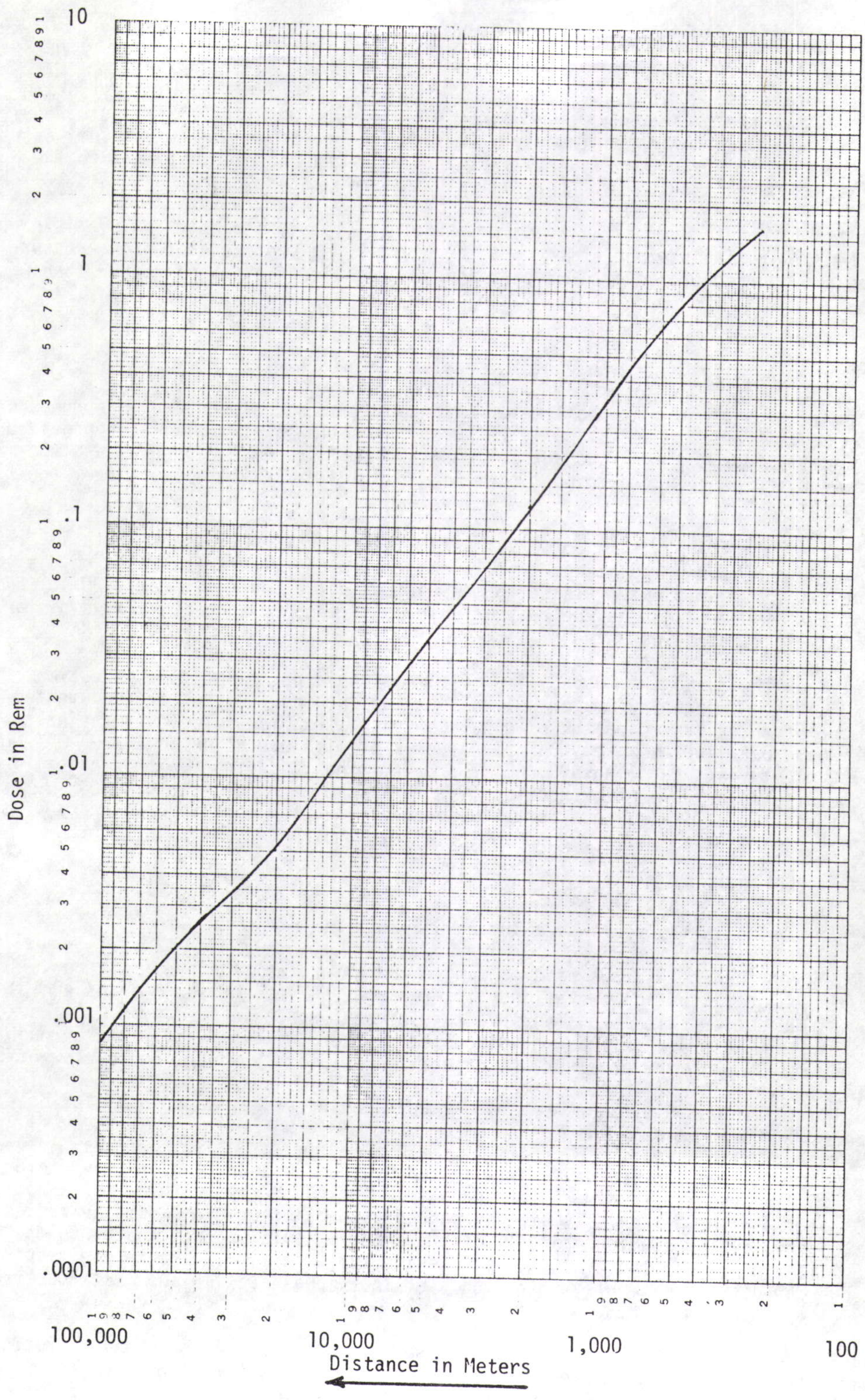

Fig. 5.1. Failure in the Air Cleaning System: 50-year Dose Commitment to Lungs. (The element of concern is insoluble uranium.)

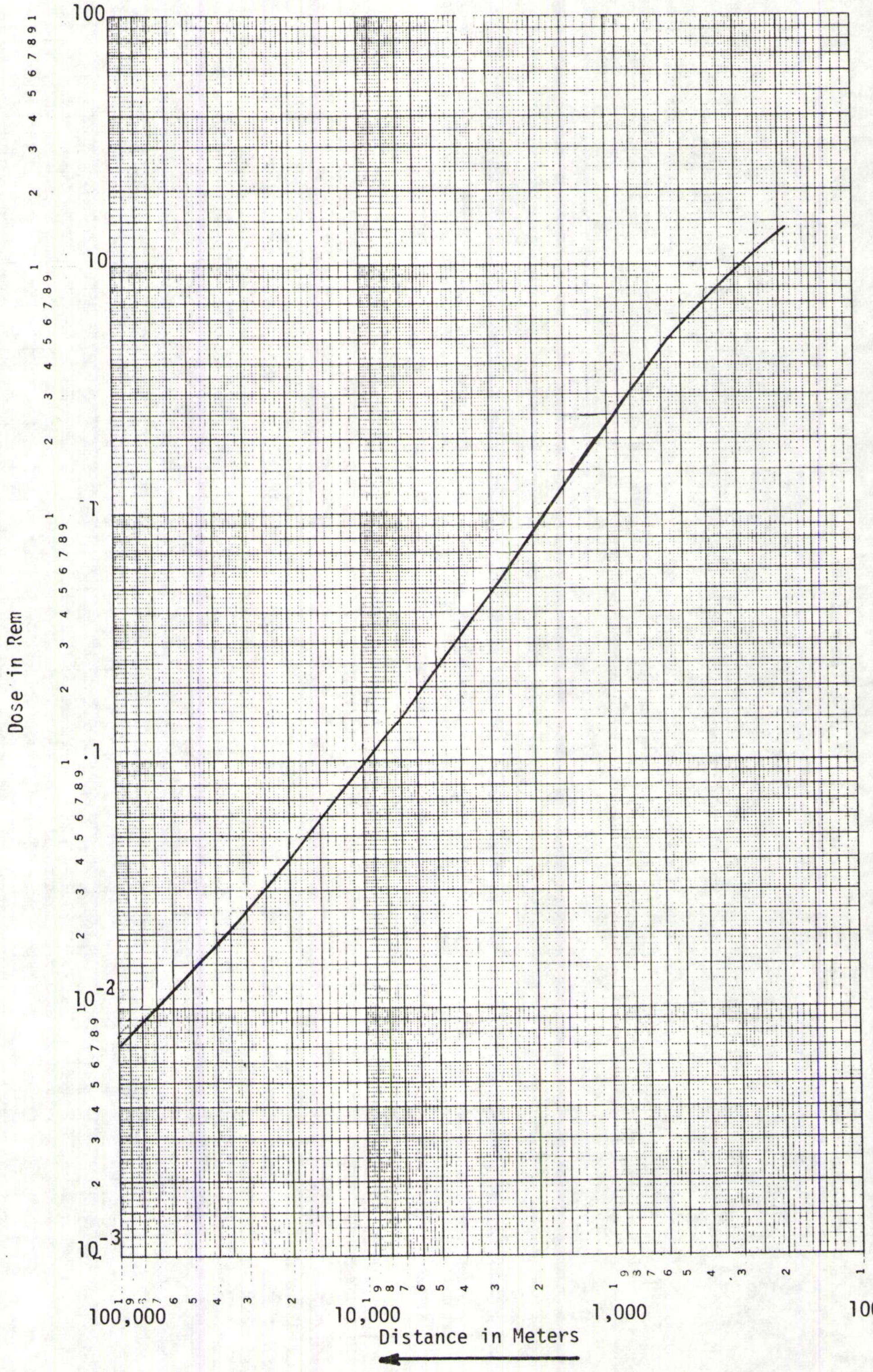

Fig. 5.2. Fire in the Solvent-Extraction Circuit: 50-Year Dose Commitment to Bone. (The element of concern is soluble uranium.)

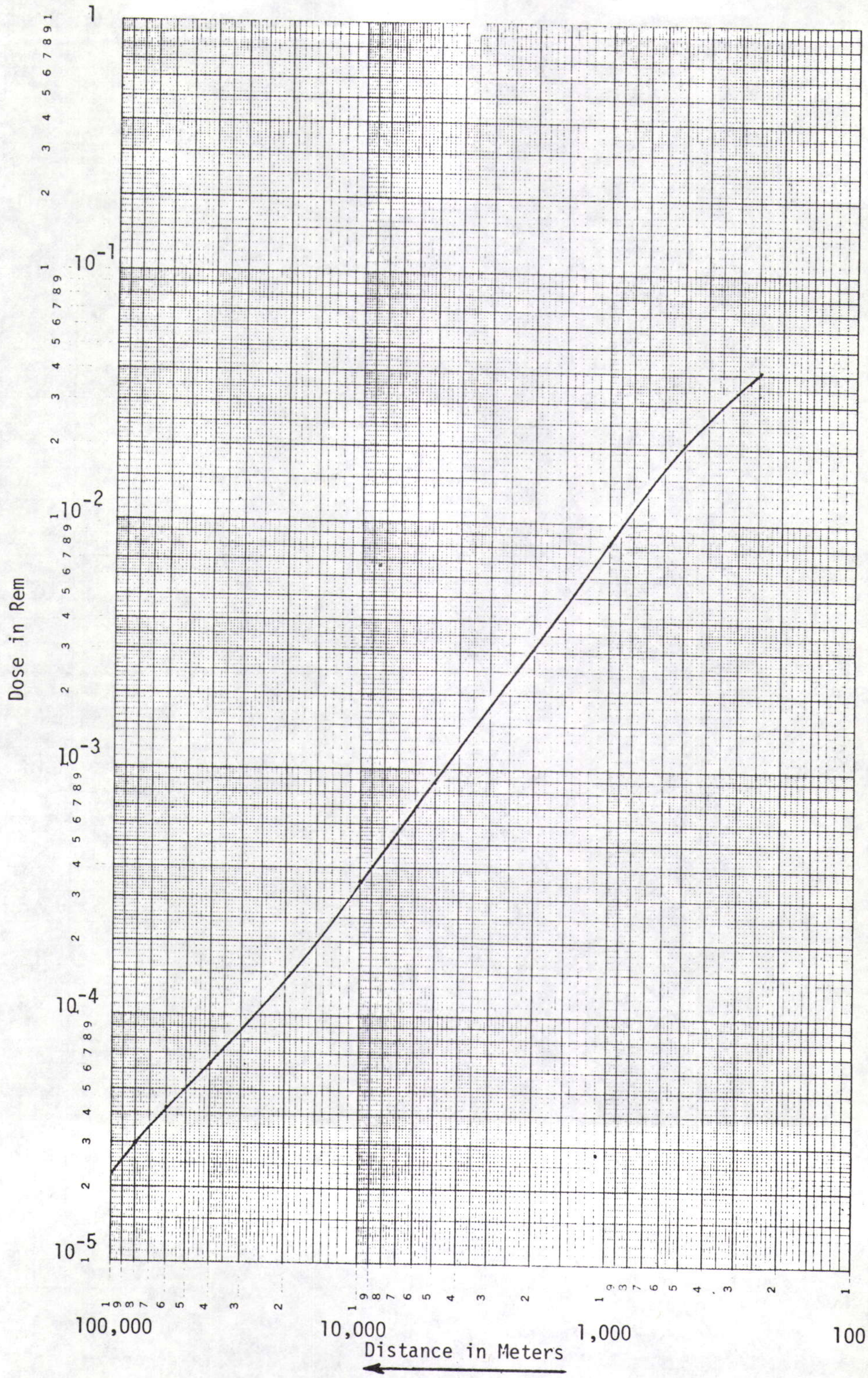

Fig. 5.3. Gas Explosion in Yellowcake Drying Operation: 50-year Dose Commitment to Lungs.

upon roughly 170,000 feet of piping per plant (which is considerably higher than the actual number of feet of piping in a typical uranium mill) and does not take into account the probability of ignition, given a failure.

5.1.3 Large Releases

The following incidents might release large quantities of radioactive materials to the environment compared with the annual release from normal operations. By virtue of complex and highly variable dispersion characteristics, however, the individual impacts will not necessarily be proportional to the total amount of radioactivity released to the environment.

5.1.3.1 Tornado

The probability of occurrence of a tornado in the 1° square in which the Atlas mill is located is negligible. Using closest available data, the probability is approximately 8×10^{-5}/yr.[8] The area is categorized as Region 3 in relative tornado intensity,[9] i.e., for a "typical" tornado, the wind speed is 239 miles/hr (385 km/hr), of which 190 miles/hr (305 km/hr) is rotational and 49 miles/hr (79 km/hr) is translational. None of the mill structures is designed to withstand a tornado of this intensity.

The nature of the milling operation is such that little more could be done to secure the facility with advance warning than without it. Accordingly, a "no warning" tornado was postulated. Moreover, since it is not possible to accurately predict the total amount of material dispersed by the tornado, a highly conservative approach was adopted. Because the yellowcake product has the highest specific activity of any material handled at the mill and as much as 46 MT of product may be accumulated prior to shipment, it is assumed that the tornado lifts 10,031 lb (4550 kg) of yellowcake.

A conservative model,[10] which assumes that all of the yellowcake is in respirable form, was used for the dispersion analysis. The model assumes that all of the material is entrained in the tornado as the vortex passes over the site. Upon reaching the site boundary, the vortex dissipates, leaving a volume source to be dispersed by the trailing winds of the storm. The material is assumed to exist as a volume source representative of the velocities of the tornado, and disperses through an arc of 45°. Due to the small particle sizes postulated, the settling velocity is assumed to be negligible.

The model predicts a maximum exposure at a distance of approximately 2.5 miles (4 km) from the mill, where the 50-year dose commitment to the lungs of an individual is estimated to be approximately 1.1×10^{-7} rem. The 50-year lung dose commitment as a function of distance is plotted in Figure 5.4.

5.1.3.2 Release of Tailings Slurry

The total discharge from the acid and alkaline tailings washings to the tailings pond will be approximately 163 MT/hr: 45 MT/hr of dry solids and 118 MT/hr of liquids (54 MT/hr of liquids are recycled back through the process). Since the mill began operations in 1956, an estimated 8 million MT of tailings has accumulated in the tailings pond. At the applicant's planned throughput due to expanded operations, approximately 4 million MT of tailings will be added to the existing 115-acre (47 ha) pond during future operations. Inadvertent release of this material to the environment might result from an overflow of the tailings slurry, a rupture in the tailings distribution piping, or a failure of the tailings dam. Failure of the tailings dam could be attributed to a destructive earthquake, flood-water breaching, or structural failure.

For the anticipated rates of precipitation during the life of the mill, the tailings pond could overflow only if the processing system were allowed to operate unattended for several weeks. In actuality, the pool level will be inspected frequently and the system would be turned off to prevent overflowing.

According to the applicant's evaluation, a maximum water surface elevation of 3976 feet MSL (1212 m) is predicted under the combined events of the 100-year flood on the Colorado River at Cisco and the probable maximum flood on the local drainage areas between Cisco and the site, taking into account the coincident wind-generated wave run-up. This water level would not result in a breach of the tailings pond, as the existing height of the embankment is 4028 feet MSL (1228 m) (see Fig. 2.5). In addition, a more conservative staff study of PMF for the Colorado River indicated that while the toe of the tailings pond would be inundated up to several feet, no failure of the dike would occur.

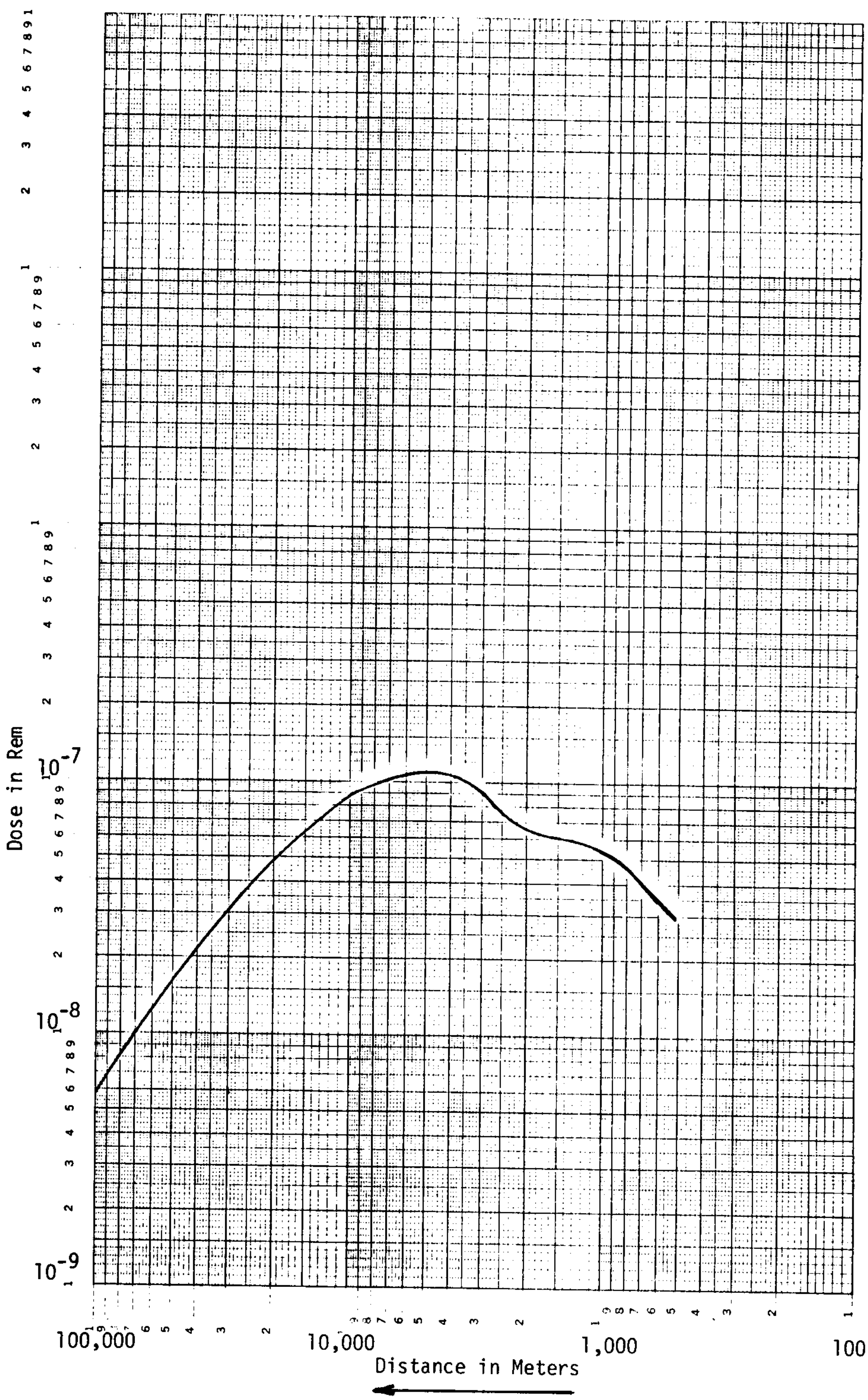

Fig. 5.4. Tornado Damage: 50-year Dose Commitment to Lungs.

The Atlas mill site is in the Zone 1 ("minor damage") seismic risk category (intensities V to VI on the Modified Mercalli Scale).[11] A review of the historic seismicity and seismotectonic relationships reveals two potential sources that could result in the maximum probable earthquake at the site, each of which could generate horizontal accelerations of about 0.02 g. Introducing a margin of conservatism, the applicant has used a design horizontal acceleration of 0.05 g, characteristic of Zone 2 (intensities VI to VII on the Modified Mercalli Scale). A structural analysis of the embankment conditions anticipated for the future additional 4 million MT of storage revealed a minimum factor of safety 1.5 under conditions of the design horizontal acceleration.

From the foregoing discussion, it appears that a natural disaster of sufficient intensity to result in a release of the tailings slurry to the environment would occur on a frequency of less than once in a hundred years. Even if the frequency were known accurately, it would be difficult to predict the magnitude of the release. However, tailings slurry releases have occurred in the past, including two incidents on record at the Atlas mill site. On 6 February 1967, there was an auxiliary decant line failure, resulting in the release of 440,000 gallons of tailings liquid with an average Ra-226 concentration of 5.5×10^{-8} μCi/ml.[6] The other incident occurred on 23 November 1968, involving a tailings distribution-pipe break and the loss of 35,000 gallons of tailings slurry. Since then, the applicant has undertaken some mitigating measures, including the replacement of antiquated tailings piping system and frequent piping inspections. The consequences associated with the two events have been documented to varying levels of detail in reports to the NRC (AEC) and will be used to estimate the nominal Atlas mill release, taking into account the applicant's mitigating measures. Table 5.1 summarizes a recorded tailings release incidents during 1959-1971.[6]

Table 5.1. Summary of Accidental Tailings Slurry Releases, 1959-1971[a]

Cause	Solids Released, lb (kg)	Liquids Released, gal (l)	Reached Watercourse
Flash flood	3×10^7 (14×10^6)	3×10^6 (1×10^7)	Yes
Dam failure	2×10^6 (9×10^5)[b]	2×10^5 (8×10^5)	Yes
Dam failure	1×10^6 (5×10^5)	1×10^5 (4×10^5)[b]	No
Dam failure	4×10^5 (2×10^5)	5×10^4 (2×10^5)[b]	Yes
Pipeline failure	7×10^5 (3×10^5)	5×10^4 (2×10^5)	Yes
Flooding	2×10^8 (1×10^8)[b]	2×10^7 (8×10^7)	Yes
Pipeline failure	1×10^5 (5×10^4)	2×10^4 (8×10^4)	Small amount
Pipeline failure[c]	4×10^6 (2×10^6)[b]	4×10^5 (2×10^6)	Yes
Dam failure	2×10^6-3×10^7 $(1\text{-}14 \times 10^6)$[b]	3×10^5-3×10^6 $(1\text{-}11 \times 10^6)$	Yes
Pipeline failure[c]	2×10^5 (1×10^5)[b]	3×10^4 (1×10^5)	Yes
Dam failure	2×10^4 (9×10^3)[b]	2×10^3 (8×10^3)	No
Pipeline failure	No quantitative information		No

[a]From "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, U. S. Atomic Energy Commission, Fuels and Materials, Directorate of Licensing, April 1974.

[b]Assuming equal weights of solids and liquids released, and density of the liquids to be approximately 2.4 lb/gal (1.1 kg/l).

[c]Occurred at the Atlas mill.

On the basis of these historical data, the average release from tailings dike failure or flooding was approximately 3.9×10^6 gallons (1.5×10^7 l) of liquids and 3.9×10^7 lb (1.5×10^7 kg) of solids. Nine out of 12 of the releases for which data are available reached the watercourse, and of the 12 recorded incidents, seven involved dam failure or flooding. Thus, considering the 287 mill-years of operation in the period (or 240 mill-years, normalized to 390,000 MT ore/yr), the likelihood of release from the tailings pond to the watercourse is approximately 2×10^{-2} per plant-year. This is a conservative estimate of tailings impoundment failure, as many of the early dikes were poorly constructed.

As discussed in Section 5.1.1, most failures in the tailings distribution piping would result in release of the slurry to the tailings pond and not to the environment. However, if the failure were to occur in the feedline piping between the mill and the tailings area, the slurry could conceivably reach the river. From Table 5.1 data, the average release to the watercourse from piping failures was approximately 1.3×10^5 gallons (5.2×10^5 l) of liquids and 1.3×10^6 lb (6.2×10^5 kg) of solids. Furthermore, on the same basis as the dike failure estimate, the likelihood of tailings release from failure of the piping is approximately 1.5×10^{-2} per plant-year. Since both the historical consequences and likelihood of piping failures are lower than those of dike failures, only releases from dike failures or flooding will be considered in the discussion of the impact of a tailings slurry release that follows.

The solid tailings are coated with acid solution and are predicted to have a radiological composition of approximately 29 μCi/MT of U-238, 29 μCi/MT of U-234, 540 μCi/MT of Th-230, and 570 μCi/MT of Ra-226. Because of losses due to seepage, evaporation from the disposal area, and entrapment in the tailings solids, the composition of the liquid phase is difficult to predict. In addition to dissolved minerals from the ore, the tailings solution contains trace quantities of components of the organic phase (mostly kerosene) of the solvent extraction step in the milling circuit. Table 5.2 shows the composition of the tailings pond solution as predicted from the applicant's measurements on a synthetic raffinate. Several of the concentrations may not be representative of actual mill conditions when both acid and alkaline leach circuits are in operation. The concentration of Th-230 is particularly difficult to predict, as thorium solubility is strongly dependent on solution acidity.* However, use of the value given in Table 5.2 for accident impact assessment is judged to be conservative, since most of the thorium would be expected to precipitate out of solution when the tailings slurry is diluted with river water, because of its very low solubility at near neutral pH.[13]

Table 5.2. Concentrations of Radionuclides and Chemicals in the Tailings Pond

Radionuclide	Concentration, μCi/ml	Maximum Permissible Concentration in Unrestricted Areas, μCi/ml[a]
U-238	6×10^{-7}	4.0×10^{-5}
U-234	6×10^{-7}	3.0×10^{-5}
Th-230	5×10^{-8}	2.0×10^{-6}
Ra-226	1×10^{-7}[b]	3.0×10^{-8}
Chemical	**Concentration, mg/l**	**NAS Water Quality Standards for Public Water Supplies, mg/l[c]**
As	7	0.1
$SO_4^{=}$	100,000	250
Cl^-	300	250
TDS[d]	150,000	NS
V_2O_5	300	NS

[a] 10 CFR 20.

[b] This concentration reflects earlier operations using barium treatment to reduce radium levels when effluent was discharged to the Colorado River. Since current and future operations will be closed-cycle, a more conservative radium concentration of 3×10^{-7} μCi/ml is used in the impact calculations.

[c] "Water Quality Criteria 1972," A Report of the Committee on Water Quality, National Academy of Sciences. National Academy of Engineering, prepared for the U. S. Environmental Protection Agency, 1972.

[d] Total dissolved solids.

[e] No Standard.

*Reported concentrations of Th-230 in tailings solutions range from on the order of 10^{-4} μCi/ml, typical of the acid leach process,[12] to $\sim 10^{-10}$ μCi/ml for an alkaline leach circuit.[3]

A fraction of the estimated 3.7×10^7 lbs (1.8×10^7 kg) of solid tailings released from the impoundment area in the event of an overtopping or failure of the dam would be deposited on the high ground above the river, but a significant amount would undoubtedly reach the river approximately 820 feet (240 m) from the embankment. Most of the coarse particles would fall to the river bottom close to where they enter the river, whereas the fines would be carried by the river and ultimately deposited in the downstream sediment.

Nearly all of the estimated 3.9×10^6 gallons (1.5×10^7 l) of tailings liquids released from the impoundment would be expected to reach the river, where it would be significantly diluted. Assuming an average river flow rate of approximately 5.8×10^4 gal/sec (2.2×10^5 l/sec), the dilution would be sufficient to reduce the radium concentration below maximum permissible concentration (as given in 10 CFR 20) even if the total release occurred in a period as short as one hour.

The radiation exposure was estimated for individuals drinking Colorado River water subsequent to the postulated release. Complete mixing of the tailings liquid with river water would be expected to occur before the tailings reached the closest point at which river water might be extracted for drinking purposes, approximately five miles downstream from the mill. It is assumed that a reduction in the concentrations of radioisotopes given in Table 5.2 is the result of dilution alone, and does not include precipitation or adsorption onto bottom sediment. Then, for an average individual drinking rate of 40 fluid ounces (1.2 l) per day, the predicted 50-year dose commitment is approximately 1×10^{-4} rem to the bone.

Should a release of tailings slurry occur, the NRC and regional offices of the EPA and Coast Guard must be notified, given the approximate time of the accident, and given an estimate of the quantities of liquids and solids released from the tailings pond. Moreover, the water in the Colorado River would be sampled for chemical concentrations and radioactivity, and downstream users would be notified so that temporary curtailment of water use could be effected if the concentration of radionuclides was found to be excessive.

5.2 NON-RADIOLOGICAL ACCIDENTS

The potential for environmental effects from accidents involving non-radiological materials at the Atlas mill is small. Failure of the boiler supplying process steam to the mill could release low-pressure steam to the room, possibly causing minor injuries to workers, but not involving the release of chemicals or radioactive materials to the environment. Forced-air ventilation systems are provided in several stages of the process to dilute the chemical vapors emitted and protect the workers from the hazardous fumes. Failure of these ventilation systems might result in the interim collection of these vapors in the building air. Since the vapors are ultimately discharged to the atmosphere in either case, such a failure would have no effect on the environment.

A number of chemical reagents used in the process will be stored in relatively large quantities on the site. Specifically, storage tanks will be provided for approximately 423,000 gallons (1,600,000 l) of sulfuric acid, 7100 lb (3200 kg) of sodium chlorate, 10,500 gallons (40,000 l) of caustic soda, 7400 gallons (28,000 l) of hydrogen peroxide, and 16,600 gallons (63,000 l) of anhydrous ammonia. Additionally, several storage tanks containing kerosene, diesel fuel, gasoline, and propane are also on the site. To prevent a spill of liquid reagents from reaching the river, containment dikes have been constructed on the south side of the mill area, which drain into two containment ponds of over 7.9×10^5 gallons (3×10^6 l) capacity.

The only chemical that might seriously affect the environment is ammonia. A break in the external piping of the anhydrous ammonia tank would not result in a release since an excess flow valve would automatically close on a drop in pressure, thus preventing the escape of ammonia. It is possible that the line carrying ammonia to the storage tank from the tank truck could be ruptured, in which case the release rate would be limited to 100 g/sec of ammonia vapor. Assuming the release to be irreversible, the resulting concentrations of ammonia as a function of distance from the mill are shown in Figure 5.5. Beyond 6.2 miles (10 km) this concentration is below the 600 $\mu g/m^3$ short-term air quality standard derived from State of Colorado regulations (at 1/30 threshold limit values).[13] Beyond 2300 feet (700 m) under both the 40,000 $\mu g/m^3$ needed to produce a detectable odor and the 69,000 $\mu g/m^3$ recommended limit for prolonged human exposure.[14] Thus, the released ammonia would not be noticed by offsite residents and would pose no health risk in the environment.

On the other hand, workers at the mill within a radius of 100 meters from the ruptured line could be exposed to an ammonia concentration in excess of 10^6 $\mu g/m^3$. At these levels, there exists a risk of suffocation due to tracheal spasm or, for individuals with myocardial disease, of heart attack. Following the initial detection of a strong ammonia odor (at approximately 40,000 $\mu g/m^3$), however, most healthy individuals should be able to escape the area, possibly suffering some permanent damage through pulmonary or ocular tissues.

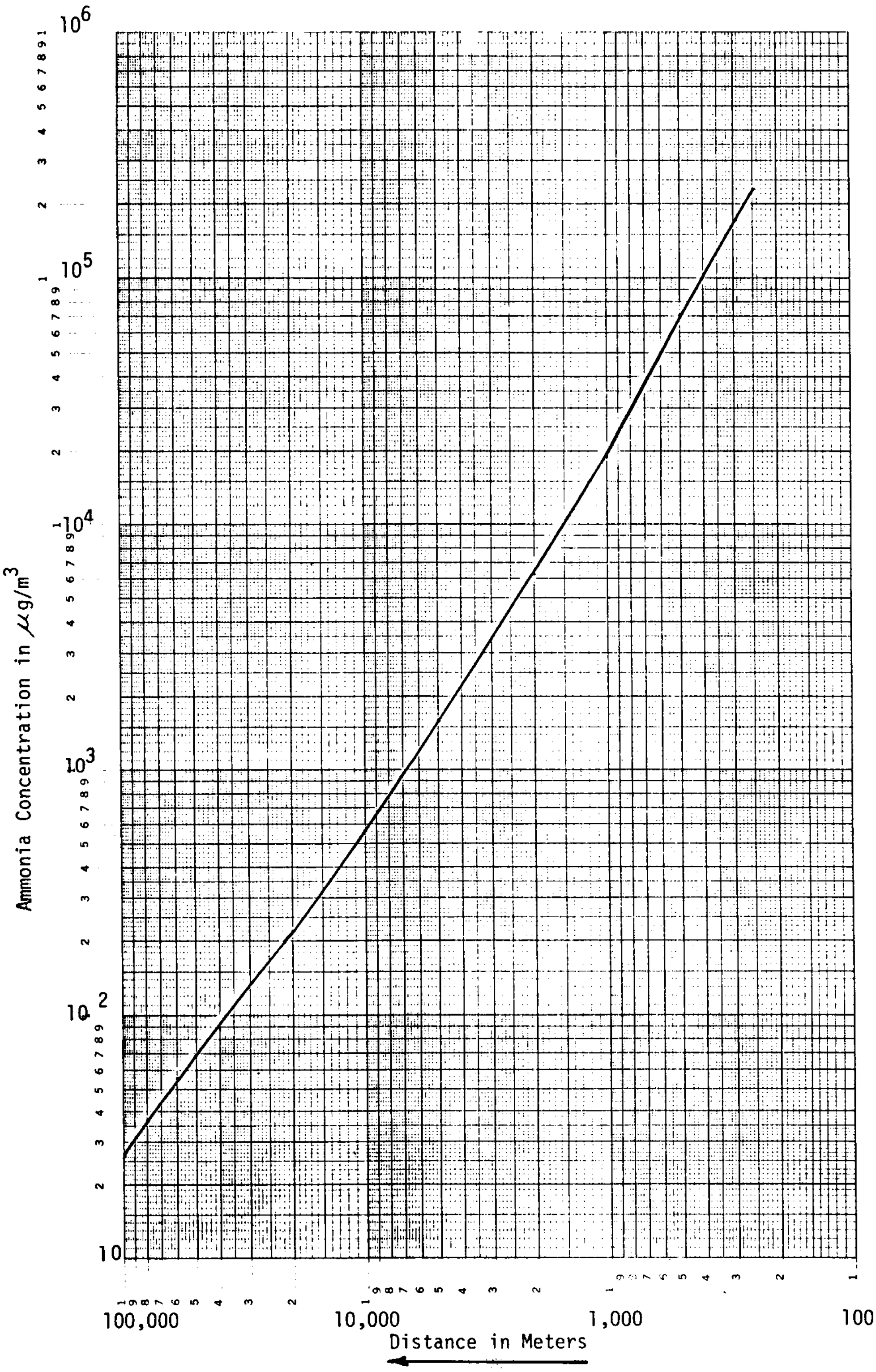

Fig. 5.5. Toxic Chemical Tank Failure: Ammonia Release.

5.3 TRANSPORTATION ACCIDENTS

Transportation of materials to and from the mill can be divided into three categories: (1) shipments of refined yellowcake from the mill to the uranium hexafluoride conversion facility, (2) shipments of ore from the mine pit to the mill, and (3) shipments of process chemicals from suppliers to the mill. An accident in each of these categories has been posutlated and analyzed, and the results are given in the following discussion.

5.3.1 Shipments of Yellowcake

Refined yellowcake product is generally packaged in 55-gallon (208 l), 18-gauge drums holding an average of 364 kg (800 lbs) and classified by the Department of Transportation (DOT) as Type A packaging (49 CFR Parts 171-189 and 10 CFR Part 71). It is shipped by truck an average of 1370 miles (2220 km) to a conversion plant, which transforms the yellowcake to uranium hexafluoride for the enrichment step of the light water-cooled reactor fuel cycle. An average truck shipment contains approximately 45 drums, or 16 MT (17.5 tons) of yellowcake. Based upon the Atlas mill capacity of 400,000 MT (440,000 tons) of ore annually and a yellowcake yield of 650 MT (700 tons) approximately 40 such shipments are required annually.

From published accident statistics,[15 18] the probability of a truck accident is in the range of 1.6 to 2.6 x 10^{-6}/mile (1.0 to 1.6 x 10^{-6}/km). Truck accident statistics include three categories of traffic accidents: collisions, noncollisions, and other events. Collisions involve interactions of the transport vehicle with other objects, whether moving vehicles or fixed objects. Noncollisions are accidents in which the transport vehicle leaves the transport path or deviates from normal operation in some way, such as by rolling over on its top and side. Accidents classified as other events include personal injuries suffered on the vehicle, records of persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring on a standing vehicle. The likelihood of a truck shipment of yellowcake from the mill being involved in an accident of any type during a one-year period is approximately 0.14.

The ability of the materials and structures in the shipping package to resist the combined physical forces arising from impact, puncture, crush, vibration, and fire depends on the magnitude of the forces. These magnitudes vary with the severity of the accident, as does the frequency with which they occur. A generalized evaluation of accident risks by NRC classifies accidents into eight categories, depending upon the combined stresses of impact, puncture, crush and fire. On the basis of this classification scheme, conditional probabilities (i.e., given an accident, the probabilities that the accident is of a certain magnitude) of the occurrence of the eight accident severities were developed. These fractional probabilities of occurrence for truck accidents are given in Column 2 of Table 5.3[20]. In order to assess the risk of a transportation accident, it is necessary to know the fraction of radioactive material that is released when involved in an accident of a given severity. Two models are postulated for this analysis, and the fractional releases for each model are shown in Columns 3 and 4 of Table 5.3[20]. Model I assumes complete loss of the drum contents; Model II, based upon actual tests, assumes partial loss of the drum contents. The packaging is assumed to be Type A drums containing low specific activity (LSA) radioactive materials. Considering the fractional occurrence and the release fraction (loss) for Model I and Model II, the expected fractional release in any given accident is approximately 0.45 and 0.03, respectively.

Table 5.3.

Fractional Probabilities of Occurrence and Corresponding Package Release Fractions for Each of the Release Models for LSA and Type A Containers Involved in Truck Accidents

Accident Severity Category	Fractional Occurrence of Accident	Model I LSA & Type A	Model II LSA & Type A
I	0.55	0	0
II	0.36	1.0	0.01
III	0.07	1.0	0.1
IV	0.016	1.0	1.0
V	0.0028	1.0	1.0
VI	0.0011	1.0	1.0
VII	8.5×10^{-5}	1.0	1.0
VIII	1.5×10^{-5}	1.0	1.0

For Model I and Model II, the quantity of yellowcake released to the atmosphere in the event of a truck accident is estimated to be roughly 7400 kg (16200 lbs) and 500 kg (1100 lbs), respectively. Most of the yellowcake released from the container would be deposited directly on the ground in the immediate vicinity of the accident. Some fraction of the released material, however, would be dispersed to the atmosphere. Battelle has developed expressions for the dispersal of similar material to the environment based on actual laboratory and field measurements over several years.[18] The following empirical expression was derived for the dispersal of the material to the environment via the air following an accident involving a release from the container:

$$f = 0.001 + 4.6 \times 10^{-4} (1-e^{-0.15ut}) u^{1.78},$$

where:

f = the fractional airborne release,

u = the wind speed at 15.2 meters (50 ft) expressed in m/sec, and

t = the duration of the release, in house

In this expression, the first term represents the initial "puff" immediately airborne when the container is failed in an accident. Assuming that the wind speed is 5 m/sec (10 miles/hr), and that 24 hours are available for the release, the environmental release fraction is estimated to be 9×10^{-3}. Assuming insoluble uranium all particles of which are in the respirable size range and a population density of 160 people/mi^2 characteristic of the eastern Unites States[21], the consequences of a truck accident involving a shipment of yellowcake from the mill would be a 50-year dose commitment[a] to the general population of approximately 13 and 0.9 man-rem to the lungs for Models I and II, respectively.

A recent accident (September 1977) involving a commercial carrier, carrying 50 steel drums of uranium concentrate overturned and spilled an estimated 6800 kg (15,000 lbs) of concentrate on the ground and in the truck trailer. Approximately three hours after the accident, the material was covered with plastic to prevent further release to the atmosphere. Using the above formula and values of wind speed for a fractional airborne release for these three hours duration of release, approximately 56 kg (123 lbs) of U_3O_8 would be released to the atmosphere. The consequence of this accident would be a 50-year dose commitment to the general population of 11 man-rem for a population density of 160 people per square mile. The consequence for the accident area where the population density is estimated to be 2.13 people per square mile would be a 50-year dose commitment of 0.146 man-rem. This can be compared to a 50-year integrated lung dose of 19 man-rem from natural background.

The applicant has committed to submit to the NRC an emergency action plan for yellowcake transportation accidents. This emergency action plan is intended to assure that personnel, equipment, and materials are available to contain and decontaminate the accident area. Submittal of this plan will be a license condition.

5.3.2 Shipments of Ore to the Mill

According to the applicant, the average distance to the mill from the producing mines is approximately 80 miles (130 km), and roughly 4×10^6 vehicle-kilometers* are required annually to haul the ore by truck to the mill. On the basis of truck-accident probabilities cited in the previous section, approximately five truck accidents involving the transport of ore to the mill would be expected annually. Actually, the applicant has experienced less than one spill per year (at 65% of the expanded capacity).

The ore as it comes from the mine contains a significant fraction of moisture and has a lower percentage of fines than ore after it has been crushed. For purposes of analysis, it is conservatively assumed that the ore contains 0.1% dust by weight, and that in an accident, all of this dust would be released from the truck and be available for dispersal. Furthermore, the environmental release factor of 9×10^{-3} derived in the previous section from the Battelle formula is assumed valid.

Based on the foregoing assumptions, the quantity of dispersible ore released to the atmosphere in the event of a truck accident is estimated to be roughly 3.8 ounces (110 g). Assuming that all of this dust is in the respirable range, the estimated 50-year dose commitment to the lungs is plotted in Figure 5.7 as a function of distances from the spill (assuming short-term dispersion characteristics appropriate to the mill site).

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*Updated for the expended capacity cited in recent documentation.

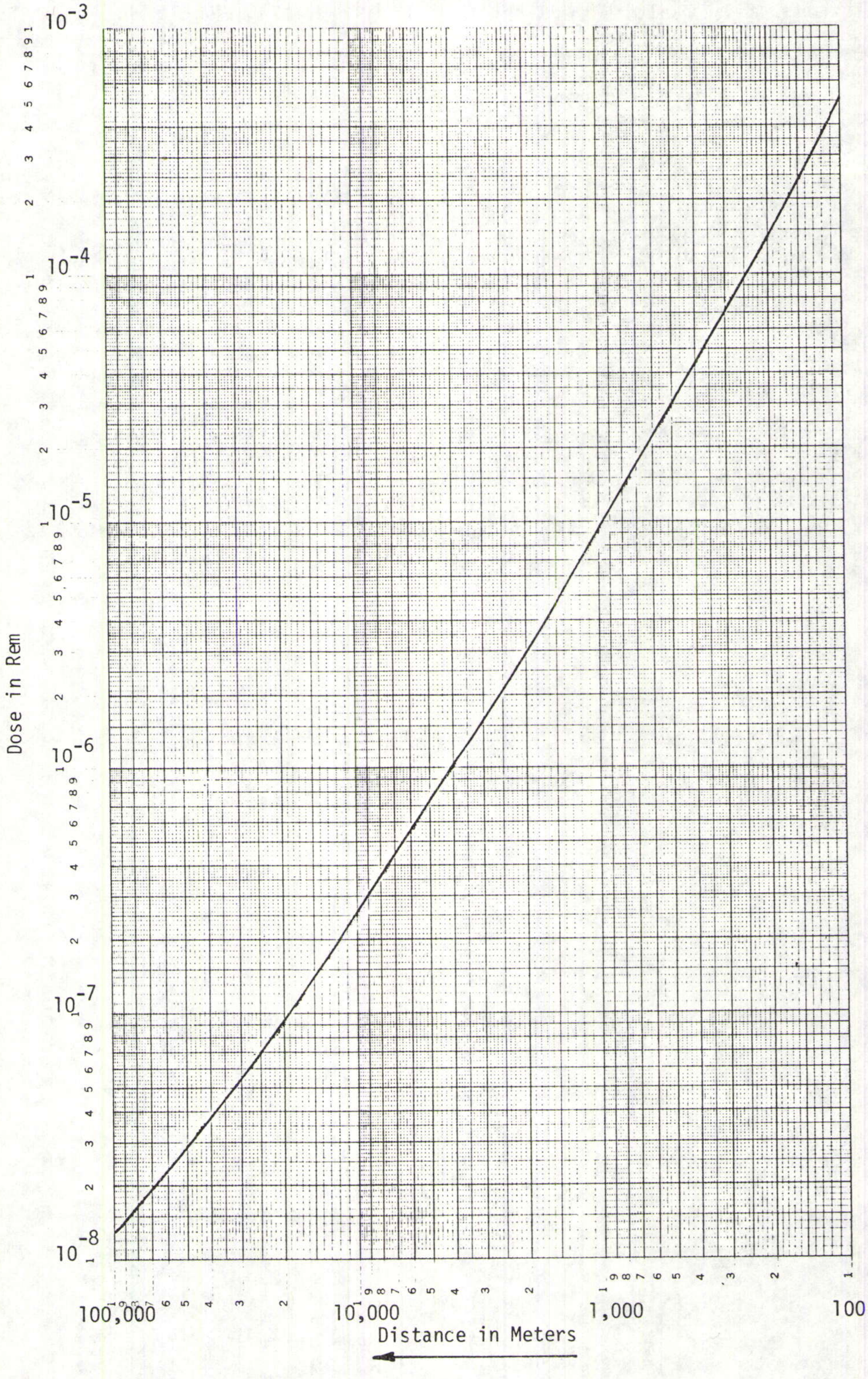

Fig. 5.7. Transportation Accident during Uranium Ore Haulage: 50-year Dose Commitment to Lungs.

5.3.3 Shipments of Chemicals to the Mill

Truck shipments of anhydrous ammonia to the mill, if involved in a severe accident, could conceivably result in a significant environmental impact. Approximately 135 shipments of anhydrous ammonia are made annually in 5000-gallon (18,900 l) tank trucks from a supplier located approximately 110 miles (180 km) from the mill.

The annual U. S. production of anhydrous ammonia which is shipped in that form is approximately 6.9×10^6 MT. It is estimated that about 26% of the shipments are made by truck (with the remainder by rail, pipeline, and barge). Assuming that the average truck shipment is roughly 19 MT, approximately 93,000 truck shipments of anhydrous ammonia are made annually. From accident data collected by DOT,[19] there are about 140 accidents per year involving truck shipments of anhydrous ammonia.* For an estimated average shipping distance of 350 miles (560 km), the resulting accident frequency is roughly 4.3×10^{-6} per mile (2.7×10^{-6} per km). The DOT data also reveal that a release of ammonia [1700 lb (770 kg) on the average] resulted from approximately 80% of the reported incidents, and that an injury to the general public occurred in roughly 15% of the reported incidents involving a release. (Most of the injuries were sustained by the driver.)

On the basis of these data, the probability of an injury to the general public resulting from an average shipment of anhydrous ammonia is roughly 4.8×10^{-7} per mile (3×10^{-7} per km). This would be expected to be an overestimate for shipments in the vicinity of the Atlas mill because of the relatively low population density. Nevertheless, accepting this estimate, the likelihood of an injury to the general public resulting from shipments of ammonia to the mill is predicted to be roughly 7×10^{-3} per year.

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*The DOT accident statistics are extrapolated from the number of shippers reporting, estimated at about 10% of the total number of shippers.

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21. U.S. Bureau of the Census, "Statistical Abstract of the United States; 1976". (97th edition) Washington, D.C., 1976

6. MONITORING PROGRAMS

6.1 AIR QUALITY

Meteorological monitoring equipment currently installed at the site continuously records pressure, temperature, relative humidity, wind speed, and wind direction from an area within the mill boundaries. Suspended particulate matter is monitored by 20 high-volume samplers located outside the plant at distances up to 15 miles (25 km) from the site. The trapped particles are analyzed for natural uranium content.

Mill emissions are reduced by stack emission control devices. The wetted areas of the tailings piles will generally have minimal dust-emission problems. Dust suppression may be required during particularly windy periods, and will be achieved by wetting the dry-beach areas or application of chemicals (Sec. 10.3.2).

6.2 LAND USE

Stabilization of the tailings pond and reclamation of the mill site will be performed in accordance with the Utah Mined Land Reclamation Act (Utah Code Annotated 1953, §40-81, et seq.). The applicant's reclamation plan (see Sec. 10) has been agreed upon by the Atlas mill and the State of Utah Division of Oil, Gas and Mining and Department of Natural Resources. Mitigative measures for this plan are presented in Sections 10.2 and 10.3. Surety arrangements with the State of Utah will insure that sufficient funds are available for completion of mill decommissioning and tailings reclamation.

6.3 WATER

The applicant has extensively monitored river water quality and plant effluents because of the proximity of the mill to the Colorado River. The liquid effluent monitoring programs meet NRC requirements and comply with State of Utah regulations and EPA guidelines.

The surface water monitoring programs are designed to acquire the following data:

- Radioactivity and salinity of Colorado River water above and below the plant.
- Dissolved and suspended solids in the river water pumped to the mill water treatment plant.
- Radioactivity of the tailings decant liquid.

These pre-application monitoring procedures are summarized in Table 6.1 and described in detail in the ER (Table 6.1 and Sections 6.4.2 and 6.4.5).

Information on levels and quality of groundwater has been obtained through two programs. As a part of a study of the tailings pond system, the applicant installed monitor wells to determine the groundwater gradient and to evaluate the radiological and chemical characteristics of the groundwater in the tailings pond area. Monitoring of chemical effluents, radionuclides, and water levels has been conducted since December 1972. The applicant also dug two additional monitor wells near the east boundary of its property where the groundwater is expected to be unaffected by the milling operations. These programs are also presented in Table 6.1 and explained in detail in the ER (Sections 6.4.2 and 6.4.5).

Applicant's Proposed Operational Monitoring Programs

Monthly analyses of the radionuclide content of Colorado River water at six locations will continue, using the State of Utah's "Code of Waste Disposal Regulations" as the applicable standard. Seepage water from the monitor wells, located between the tailings pond and the Colorado River, will continue to be analyzed for radionuclides and for a number of chemical parameters, including toxic materials such as arsenic and selenium (see Table 6.4). However, because direct

Table 6.1. Pre-Application Water Monitoring Programs (from ER, Table 6.1)

No. of Test	Medium Sampled	Sampling			Test Frequency	Components and Parameters Measured
		Method and Frequency	Type	Location		
			SURFACE WATER			
			Unrestricted Area			
1	Colorado River water	Monthly grab (1 gallon)		6 total (1 above & 5 below mill)	Monthly	Radionuclides; U_{nat}, Ra-226, Th-230, Po-210, (Pb-210 quarterly)
2	Colorado River water	Daily grab	Monthly composite	Pumping plant	Monthly	Cl^-, $SO_4^=$, NO_3^-, TSS, TDS. Occasionally: K^+, Fe, Na^+, F^-, Ca^{++}, Mn, Mg^{++}, total hardness, pH, conductivity.
		Orifice meter		Pumping plant	Daily	Flow rate
3a	Radium treatment pond effluent	Continuous	Monthly composite of daily samples, weighted for flow rate	Radium treatment pond discharge	Monthly	Radionuclides: U_{nat}, Th-230, Ra-226, Po-210
					Quarterly	Pb-210
3b	Radium treatment pond effluent	Same sample as for 3a			Daily	Flow rate
					Monthly	Cl^-, NO_3, SO_4, TDS, TSS, Mg^{++}, Ca^{++}, Cu, Fe, conductivity. Occasionally: Na^+, K^+, F^-, Mn
4	Reactivator sludge				Monthly estimate	Total solids discharged
			Restricted Area			
5	Radium treatment pond feed	Daily grab (400 ml)	Monthly composite weighted for flow rate	Radium treatment pond feed	Monthly	Radionuclides: U_{nat}, Th-230, Ra-226, Po-210
6	Treated feed water	Daily grab	Composite	Reactivator overflow	Weekly	Total hardness
			GROUNDWATER			
7	Tailings area	12/8/72, 2/8/73, then quarterly	Grab	12 monitor wells	Same as sampling	Water level Ra-226, Th-230 <u>Additional for 12/8/72 Samples Only</u> Po-210, U_3O_8, V_2O_5, Cl^-, $SO_4^=$, NO_3^-, Na^+, K^+, Cu, Fe, TDS, total hardness, conductance, pH
8	Atlas property, away from tailings area	Once	Grab	East side of property	Once	U_{nat}, Ra-226, Th-230, Po-210
		March 1973				

discharge to the Colorado River has been eliminated, the liquid effluent monitoring programs will be discontinued. Some of the chemical testing programs now applied to various liquid process streams, including water supply, will be continued for process control purposes.

Related Environmental Measurements and Monitoring Programs

Stream flow and water quality of the Colorado River are measured by the U. S. Geological Survey in cooperation with the State of Utah and other Federal agencies. These data are published annually by the U. S. Geological Survey in "Water Resources Data."

6.3.1 Surface Water

The amount of water withdrawn from the Colorado River for use in the mill is continuously measured by an orifice meter.

6.3.2 Groundwater

No groundwater is utilized for any mill operation. Groundwater levels are measured, however, in monitor wells with a tapeline.

6.4 SOILS

Seepage from the tailings impoundment can contribute salts to the subsurface deposits, or even to the soils between the pond and the Colorado River. However, an analysis of recent subsurface samples did not indicate that such salt accumulation has occurred.

6.5 BIOTA

6.5.1 Terrestrial

In the opinion of the staff, routine monitoring of the terrestrial biota is not warranted, because no significant impacts are expected to occur as a result of the proposed relicensing.

6.5.2 Aquatic Biota

It is the staff's opinion that routine monitoring of aquatic biota in the Colorado River is not necessary because the probability of adverse impact to indigenous aquatic communities is extremely low.

6.6 RADIOLOGICAL

6.6.1 Pre-Application Environmental Radiological Monitoring Program and Studies

The applicant has conducted milling operations since 1956. A radiological environmental monitoring program was initiated at that time and has subsequently been expanded. Details of the existing program can be found in the applicant's Environmental Report and are summarized here in Table 6.2 and Figure 6.1. Measured levels of radioactivity averaged over five years of operation are shown in Table 6.3.

Several studies have been conducted to determine the Rn-222 concentration near uranium mill tailing ponds.[1,2] The results indicate that the Rn-222 concentrations in air just above the tailings pile or in the immediate vicinity (less than 500 feet or 150 m away) did not exceed 16 pCi/l above background.

6.6.2 Future Environmental Radiological Monitoring Program

Radiological monitoring will continue throughout the entire operating phase of the mill. A modified schedule of data acquisition will be employed based on previous measurements gathered by the applicant. This revised program (summarized in Table 6.4) provides a comprehensive monitoring approach to ensure minimum radiological impact to the environment.

The surface water program for the Colorado River described in Section 4.3 will remain unchanged. Three groundwater wells located between the tailings area and the Colorado River (Fig. 6.2) will

Table 6.2. Pre-Application Environmental Radiological Monitoring Program

Environmental Element	Material Sampled	Sampling Location	Sampling Method	Sampling Frequency	Test Frequency	Isotope or Radiation Identified
Surface water	Colorado River	One site upstream of mill, five sites downstream of mill	Grab (1 gallon)	Monthly	Monthly	Gross $\beta\gamma$, U_{nat}, Ra-226 Th-230, Po-210
					Quarterly	Pb-210
Surface water	Radium treatment pond effluent	Treatment pond discharge	Grab	Daily	Monthly	Gross $\beta\gamma$, U_{nat}, Ra-226 Th-230, Po-210
					Quarterly	Pb-210
Surface water	Radium treatment pond effluent	Treatment pond feed	Grab	Daily	Monthly	Gross $\beta\gamma$, U_{nat}, Ra-226 Th-230, Po-210
					Quarterly	Pb-210
Groundwater	Test well water	12 monitor wells near tailings area	Grab	Quarterly	Quarterly	Gross $\beta\gamma$, U_{nat}, Ra-226 Th-230, Po-210
Soil	Topsoil (representative)	14 locations around site	Grab	Once	March 1973	Gross $\beta\gamma$, U_{nat}, Ra-226
Ambient air	Airborne filtered dust	20 locations onsite	High-volume	Monthly	Monthly	U_3O_8
Ambient air	Airborne filtered dust	20 locations offsite	High-volume	Quarterly	Quarterly	U_3O_8
External radiation	Ambient	12 points around tailings pond	Scintillation counter	Quarterly	Quarterly	Direct reading γ dose

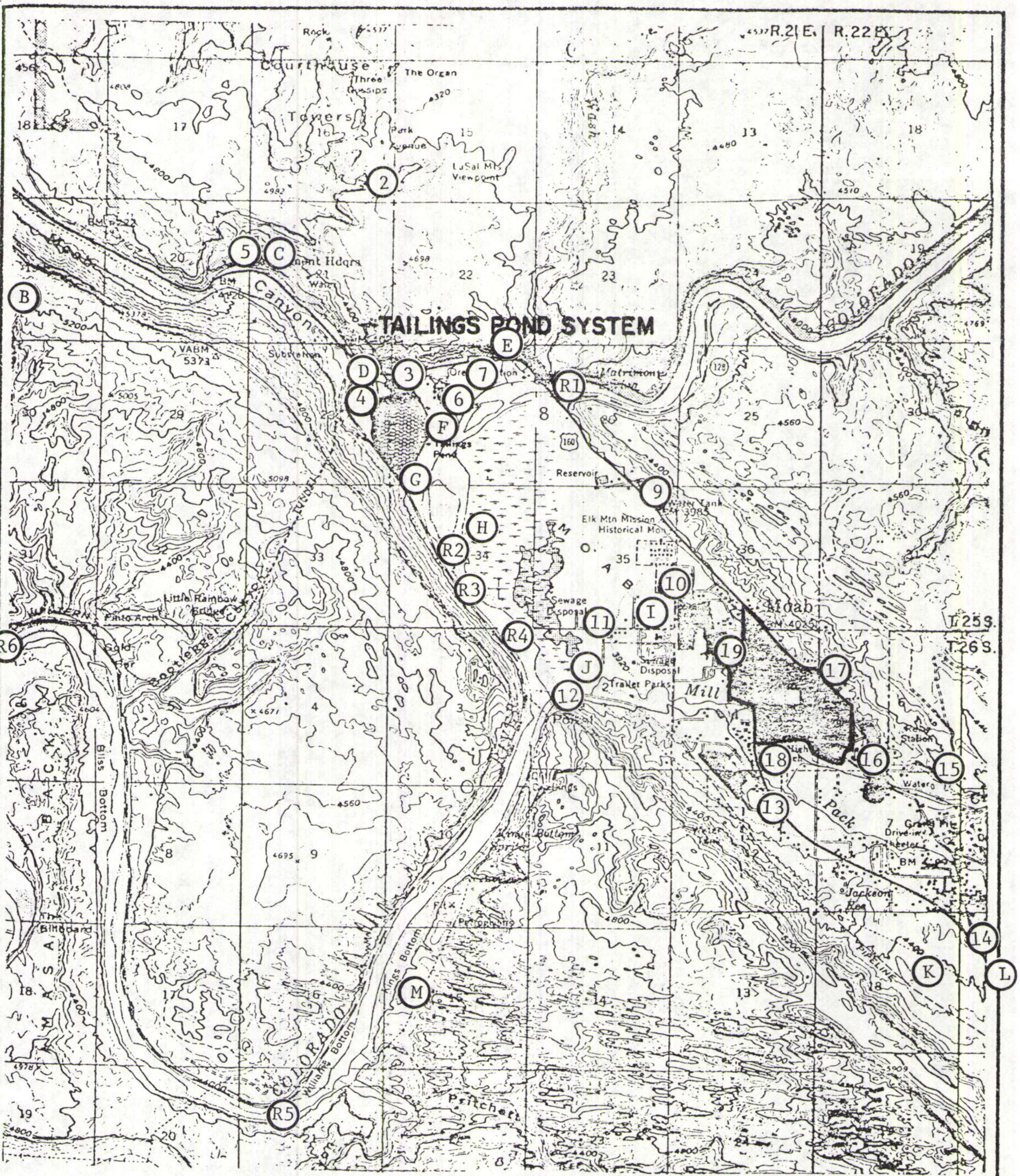


Fig. 6.1. Existing Environmental Monitoring Locations.

1-20	Airborne Particulate Samplers (LOCATIONS 1 and 20 ARE OFF MAP)
A-N	Top Soil Sample (LOCATIONS A AND N ARE OFF MAP)
R1-R6	Colorado River Water

SCALE IN MILES

1 0 1 2

Table 6.3. Levels of Radioactivity in the Environment
(measurements have been averaged over the specified time period)

Category	Location	Period	U_{nat} Activity	U_{nat} MPC	U_{nat} Unit	Ra-226 Activity	Ra-226 MPC	Ra-226 Unit	Th-230 Activity	Th-230 MPC	Th-230 Unit
Surface Water	Colorado River Upstream from mill	1971-72	7.0	6,700[a]	pCi/l	0.33	3.0[a]	pCi/l	7.1	670[a]	pCi/l
Surface Water	Colorado River Downstream from mill	1968-72	7.8	6,700[a]	pCi/l	0.34	3.0[a]	pCi/l	6.2	670[a]	pCi/l
Groundwater	Monitor Wells Near tailing pond (restricted area)	1973	130	1,000,000[b]	pCi/l	30	400[b]	pCi/l	37	50,000[b]	pCi/l
Groundwater	Monitor Wells Between tailings pond and Colorado River (unrestricted area)	1973	3400	30,000[b]	pCi/l	6	30[b]	pCi/l	12	2,000[b]	pCi/l
Ambient Air	Entrance to mill site	1968-72	140	5,000[b]	$10^{-6}\ \frac{pCi}{l\ air}$						
Ambient Air	All stations 70.5 miles from mill site	1968-72	57	5,000[b]	$10^{-6}\ \frac{pCi}{l\ air}$						
Topsoil	Greater than one mile from the site	1973	1.53 4	83[c] 57[d]	ppm U_3O_8 μrem/hr						

[a]Utah State standard for Colorado water.

[b]NRC standard (10 CFR 20, Appendix B).

[c]NRC standard based on MPC for U_{nat} in water (10 CFR 20, Appendix B).

[d]NRC standard (10 CFR 20.105), (based on 0.5 rem/yr total body dose).

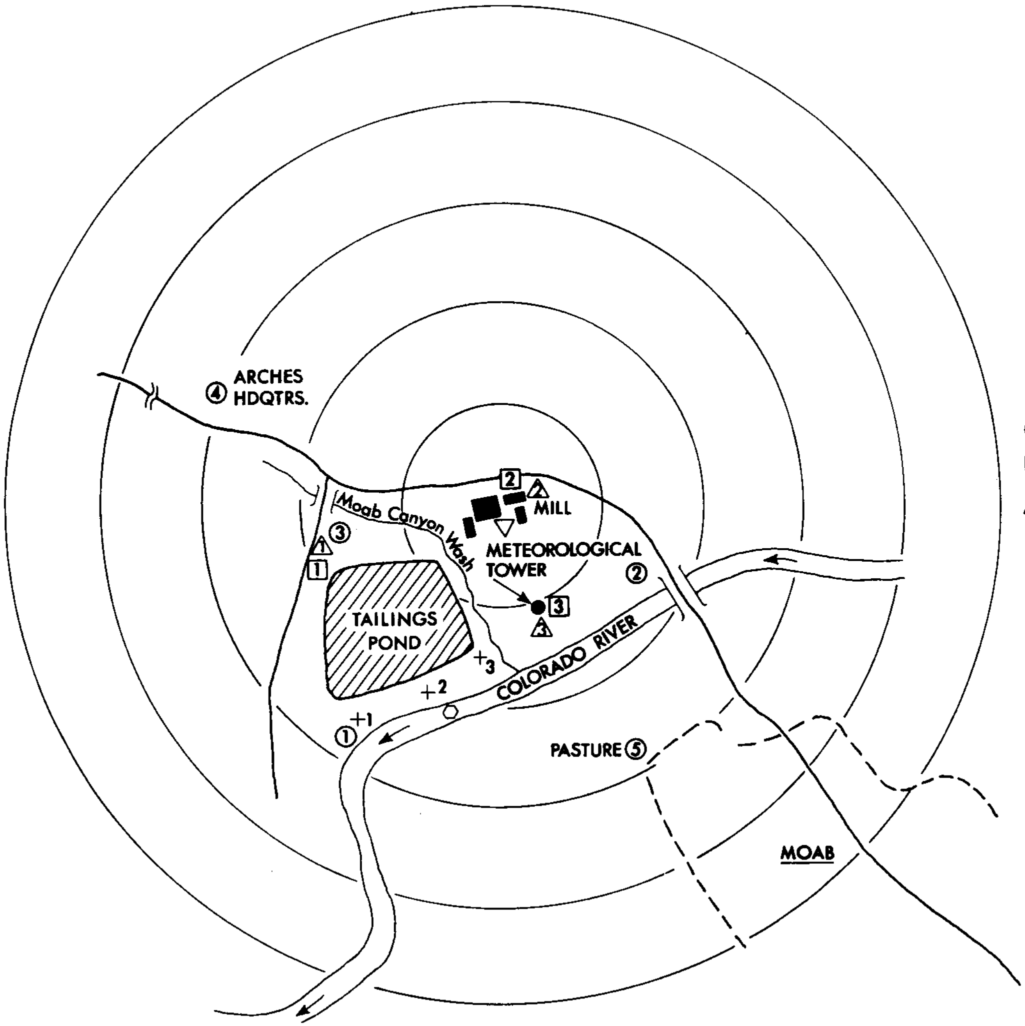
Table 6.4. Future Radiological and Non-Radiological Monitoring Program

Environmental Element	Material Sampled	Sampling: Location (see Fig. 6.3)	Sampling: Method	Sampling: Frequency	Test Frequency	Isotope or Radiation and Chemicals Identified
Surface water	Colorado River	One site upstream of mill, five sites downstream of mill	Grab (1 gallon)	Monthly	Monthly	Gross $\beta\gamma$, U_{nat}, Ra-226, Th-230
					Quarterly	Pb-210
External radiation	Ambient	Fourteen locations around tailings pond area and near site boundary and particulate collection[a] sites	Scintil-lation counter	Quarterly	Quarterly	Direct reading γ dose rate
Groundwater	Monitor well water	Three monitor wells located between mill and Colorado River and several natural sites for comparison	Grab	Quarterly	Quarterly	Gross $\beta\gamma$, U_{nat}, Ra-226, Th-230, Pb-210 K^+, Na^+, Cl^-, SO_4= NO_3^-, Cu, Fe, Mn, As, Se, TDS, conductivity, and pH[c]
Ambient air	Airborne suspended particles	Site boundary NE and SE Tex's tour center Arches park headquarters Near Moab[b] Background (remote from site)	Continuous	Filter change weekly, or as required by dust loading	Monthly (composite)	U_{nat}
					Quarterly (composite)	Ra-226, Th-230
Ambient air	Gaseous air	Same locations as airborne particulates	One week continuous per month	Monthly[c]	Monthly[c]	Rn-222
Ambient air	Particulates from yellowcake dryer[c]	Yellowcake dryer stack	Isokinetic sampling or equivalent[a]	Semi-annually[c]	Semi-annually[c]	U_3O_8 (nat) Ra-226, Th-230[c]

[a]"Standards of Performance for New Sources," Federal Register 36, No. 247, December 23, 1971.

[b]About 2.7 km from the site.

[c]Staff recommendation.



○ Airborne Particulate and Rn-222 Sampling Stations
□ On-Site Airborne Particulate Sampling Stations
△ Topsoil Sampling Stations
+ Groundwater Monitor Wells
⬡ Sediment Sampling Point
▽ Isokinetic Stack Monitoring

Figure not drawn to scale

Fig. 6.2. Future Radiological and Non-Radiological Monitoring Locations (modified from SAR, Fig. 5.5-2).

be sampled quarterly. Information from these wells will be used to ensure the integrity of the tailings pond system and to detect any migration of radionuclides toward the river.

Certain nonradiological chemicals will also be monitored to detect and quantify groundwater contamination which might precede detection of radiological contaminants.

Radioactivity in airborne suspended particles will be monitored at locations near the site boundary and outside the boundary. The selection of off-site locations was based on demographic patterns and prevailing wind conditions. These measurements will include U_{nat}, Ra-226, and Th-230. A program to measure concentrations of the radioactive noble gas Rn-222 will be initiated to ensure protection of the environment in the vicinity of the mill.

External radiation measurements will be taken in the restricted area. Fourteen points around the tailings pond and more than 50 points within the process area will be checked quarterly.

The sampling frequency and the number of sampling locations may be changed in the future when necessitated by changing environmental and demographic patterns, subject to ratification by the NRC.

References for Section 6

1. "Evaluation of Radon 222 near Uranium Tailings Piles," Joint report of the U. S. Public Health Service and the Atomic Energy Commission in cooperation with the State Health Agencies of Colorado and Utah, March 5, 1969.

2. R. N. Snelling, "Environmental Survey of Uranium Mill Tailings Pile, Mexican Hat, Utah, October 1969," U. S. Public Health Service.

7. UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

7.1 AIR QUALITY

The unavoidable impacts of the mill on the air quality of the area are few. Some increases in suspended particulates occur, but their impact on the air quality of the region is minor. The small chemical emissions anticipated will have a negligible impact on the air quality of the area.

7.2 LAND USE

The area's topography has been altered by the presence of the mill, and the restricted area will be permanently altered after the milling operation is completed. The tailings produced by the mill will remain, thus making it impossible to restore that portion of the area to its original topography.

The land on which the site is located is valuable by reason of its proximity to the city of Moab, to recreational and commercial developments that have occurred and will continue to occur around this land, and because relatively few acres in the area are privately owned. Restriction of the tailings pile area after mill closure (currently 115 acres) is a significant but unavoidable impact on the growth potential of the mill site area.

7.3 WATER

7.3.1 Surface Water

Mill operation results in the annual removal from the Colorado River of 121 gpm (241,000 m^3/hr) of water (SAR, Fig. 3.1-2, Material Balance). This is a minor withdrawal in comparison with the average flow of the river. No other impacts on water resource use are anticipated.

7.3.2 Groundwater

A minor deterioration in the quality of groundwater and river water can be expected from liquid seepage from the tailings pond. Important parameters of concern are radionuclides, total dissolved solids, and toxic elements such as arsenic. The magnitude and extent of these water quality changes, as well as mitigating factors, have been discussed in Section 4.3.

7.4 MINERAL RESOURCES

Mining of the principal uranium ore deposits will deplete the higher-grade ore bodies. However, if it becomes profitable and/or necessary, reworking of the mill tailings and the remaining lower grade ore can readily be accomplished. As there are no other known mineral deposits of economic value in the immediate vicinity of the mill, no impacts on minerals other than uranium are expected.

7.5 SOILS

Any soil profile development that may have existed at the tailings pond site prior to mill construction has been irretrievably buried under the tailings. Similarly, if the alternative tailings pond site is utilized, additional soil will be buried.

Due to the nature of the tailings material, and possible clay cap material, the staff expects that any future soils that develop over the tailings pond will be underlain by gypsiferous-like horizons, which may adversely affect soil development.

7.6 BIOTA

7.6.1 Terrestrial

All biotic communities existing at the tailings pond site prior to mill construction and operation have been destroyed. Most of the vegetation at the mill site has been destroyed or replaced by highly disturbed, weedy communities, including exotic species (ER, Section 2.8.1, p. 2-27).

7.6.2 Aquatic

The staff does not expect detectable adverse impacts on aquatic biota.

7.7 RADIOLOGICAL IMPACTS

The operations at the Atlas mill will result in the release of radioactive particulates into the air and of Ra-226, by seepage, into the Colorado river. The particulates released into the air will be deposited on the ground in the environs of the mill. This will result in an increase in the level of ambient radiation around the mill due to direct radiation. However, the increase is small and will not cause the environment around the mill to become a health hazard to the public (see Sec. 4.7.2).

The amount of Ra-226 entering the Colorado River by seepage is small, and the lowest expected flow rate of the river will provide sufficient dilution to keep the Ra-226 concentration in the river water at less than one percent of the maximum permissible concentration.

7.8 SOCIOECONOMIC IMPACTS

Any disruptions to the local community by the location and operation of the mill have occurred and have been mitigated.

8. RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

8.1 THE ENVIRONMENT

The local short-term effects of continued mill operation are those associated with any large ore-milling facility. The natural vegetation of the immediate area has been altered and its carrying capacity for select wildlife will continue to be temporarily reduced. Releases of radioactive and nonradioactive materials will be maintained at levels below applicable limits. A continuing environmental monitoring program will provide a basis for detecting and assessing impacts that might lead to long-term effects, so that timely corrective action can be taken if required.

Most local areas affected by milling will be reclaimed after operations are terminated. Except for the stabilized tailings piles, the appearance of the reclaimed site will differ little from that of the surrounding area. The short-term disruption of the landscape will not adversely affect long-term esthetics if proper mitigation measures are taken when the mill facilities are removed.

8.2 SOCIETY

The short-term societal effects of mill operation involve impacts of the work force on the local communities and impacts on the mill employees and their families. Improved transportation and new jobs will bring people and businesses into county population centers and increase the proportion of workers commuting from these centers to the mill. The magnitude of long-term socioeconomic impacts, and their effects on the work force and local population, will depend on the changing conditions within the county and its communities.

9. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

9.1 LAND AND MINERAL

9.1.1 Land

Land presently occupied by mill buildings (85 acres) and land not used for milling operations (about 200 acres of Atlas Minerals property) can be restored to its original use following mill shutdown. The tailings pile area (presently 115 acres) will be stabilized, but not available for total reclamation.

9.1.2 Mineral

The extraction, milling, and eventual use of uranium oxide produced by the Atlas operation are considered irreversible and irretrievable. However, portions of the extracted uranium can be recycled if the appropriate technologies are implemented.

9.2 WATER AND AIR

9.2.1 Water

Some water used in processing the ore and in slurrying the tailings is eventually lost through evaporation. However, because of the large volume of water available in the Colorado River, the proportionately small amount of this water that is lost is not considered to represent an irreversible or irretrievable commitment of this resource.

9.2.2 Air

Because air is not "used up" in the milling operation, and because the atmosphere is self-cleaning of pollutants at the anticipated low concentrations, no irreversible or irretrievable commitments of air resources are expected.

9.3 BIOTIC

9.3.1 Terrestrial Biota

About 200 acres (80 ha) of desert grasslands at the Atlas site has been committed to the milling of uranium, including 115 acres (47 ha) irretrievably committed to the disposal of tailings.

The staff predicts that a badlands vegetational community will develop on the tailings-disposal area following reclamation. Plant roots may penetrate into the tailings material, which resembles gypsiferous clay (see Sec. 4.6.1.2). Thus, the 115-acre (47-ha) tailings area must be considered as irretrievably committed to milling.

The desert grasslands biotic community appears to have the highest agricultural potential of any natural communities of the region, whereas the badlands community has the lowest agricultural potential. Approximately 40% of the desert grasslands of Moab Valley has been committed to the milling of uranium for the life of the project.

9.3.2 Aquatic Biota

The staff does not anticipate a detectable commitment of aquatic biotic resources.

9.4 MATERIAL RESOURCES

Although no estimates of the volumes of chemicals and reagents utilized in the milling process are available, these resources will be consumptively used and are therefore considered irretrievable and irreversible commitments. The major chemicals utilized in milling include concentrated sulfuric acid, sodium chlorate, and anhydrous ammonia.

10. ALTERNATIVES

10.1 ALTERNATIVE SITES

The use of any alternative sites for the milling operations and tailings ponds would not greatly reduce the environmental impacts at the present site and would create additional environmental impacts at a new site.

10.2 ALTERNATIVE PROCESSES

The presently utilized milling processes are in conformity with present-day state-of-the-art techniques for uranium-ore extraction processes.

10.3 ALTERNATIVE METHODS FOR TAILINGS MANAGEMENT

10.3.1 Introduction

For the purposes of this section, "tailings management" is defined as the disposition of the tailings and waste leach solutions following extraction (separation) of the uranium-bearing solutions; tailings "stabilization" is the containment of the tailings in such a way that long-term leaching of milling wastes to groundwater or subsurface waters is minimized and applicable radiation safety limits are not exceeded;[1] and "reclamation" is the restoration of affected land to a condition equal to or greater than the highest previous use. Decommissioning of the mill must therefore include disposal of the tailings in a manner that will fulfill the requirements of both stabilization and reclamation.

The staff position on effective tailings management includes the following: 1) the tailings disposal area should be (a) operated such that seepage of toxic materials to groundwater is eliminated or reduced to the maximum extent reasonably achievable, and (b) operated such that blowing of tailings to unrestricted areas is eliminated; 2) after cessation of plant operation, the disposal area should be stabilized in a manner that will reduce direct gamma radiation to essentially that of background and radon emanation to about twice background; 3) following successful stabilization, the need for ongoing monitoring and maintenance programs should be eliminated; and 4) the applicant should provide surety arrangements ensuring that sufficient funds are available to complete stabilization and reclamation plans including mill decommissioning.

Engineering techniques to control pollutants from tailings storage, both during operational and postoperational stages of a milling project, have been demonstrated. The unique characteristics of each facility must be identified, and then appropriate environmental controls must be applied. Alternatives presently available or feasible (i.e., potentially available with existing technology and within legal constraints) are discussed in Section 10.3.2. The number of options for stabilization and reclamation of the mill tailings at the Atlas mill is constrained by the fact that the mill has been in operation for about 20 years, and considerable amounts of waste tailings have already accumulated.

10.3.2 Alternatives

Alternative 1

Alternative 1 consists of continued operation of the existing tailings retention area in much the same manner as in the past. Blowing of tailings to unrestricted areas during normal operations would be prevented by the use of chemical crusting agents. The entire area would be fenced.

Reclamation will begin as soon as the area has reached sufficient dryness (probably within two years following mill shutdown). The pile would be shaped and contoured such that slime tailings will be covered by at least five feet of non-slime tailings and to promote runoff from the pile. The tailings would be capped with clay imported from off site, in turn overlain by silty fine sand obtained from the site and one foot of topsoil. The thickness of the clay layer proposed by the applicant would be one foot over non-slimes areas and would be 1.5 feet in areas where five feet of non-slimes overlie slimes. The thickness of silty fine sand proposed by the applicant would be 2.3 feet in non-slimes areas and 2.7 feet in areas where five feet of non-slimes overlie slimes. After covering, the area would be revegetated with appropriate plant species.

The clay, sand, and topsoil above the tailings pile will substantially reduce the radiation hazard, but may be inadequate to prevent the penetration of plant roots into the tailings. Such penetration would result in uptake of radionuclides and toxic elements into aerial portions of the vegetation, thus providing a pathway for their entry into the food chain. Additionally, there is evidence that plants can remove radon from soil and release it above the ground,[2] perhaps through the transpiration stream of the plant. The depth of overburden and soil necessary to permanently isolate the tailings from the biosphere will depend on the types of plant species used to revegetate the pile. For example, the roots of big bluestem, switchgrass, and Indian grass can extend downward to 7, 11, and 9 feet, respectively.[3,4] The species in the seed mixture proposed by the applicant for revegetation includes Western wheatgrass, the roots of which can reach depths of up to seven feet. However, it is believed that the hostile environment provided by the tailings will preclude root penetration into these materials. Tailings are generally barren of plant nutrients, and this accounts in large part for their general inability to support natural vegetation. In addition, the tailings will have a pH of about 1.5 to 3.0, and will contain high concentrations of sulfates with heavy metals in lesser amounts. The low pH of the tailings would be highly detrimental to plant growth. Also, heavy metal toxicity has been shown to prevent successful revegetation of the tailings.[5]

It appears that these conditions will preclude vertical penetration of roots through the soil cover and into the tailings, but could instead promote lateral spread of the root systems within the cover soils as has been noted for revegetated acid coal mine wastes.[6]

Uptake of radium or radon by plant roots therefore is not expected to be of concern.

The applicant proposes to minimize the effects of dust during operation by the use of appropriate measures to keep the particles within the property fence. Without appropriate control measures, wind erosion of tailings would result in a reduction of air quality and deposition of radioactive particles on the soil and vegetation and into aquatic systems. Such deposition can introduce radioactive material into the food chain via foraging animals. The presence of solid particles or dust (particularly sand) on vegetation may increase wear on the teeth of these animals and could reduce plant productivity by shielding them from sunlight. Monitoring to determine any contamination by materials blown from the tailings pile is described in Section 6.4.

The relatively permanent alternatives (such as concrete, asphalt, PVC or similar sheets, or vegetative cover) for the control of dust are inappropriate for use during mill operation because the tailings surface will continue to increase in elevation by about 5 feet (1.5 m) per million tons of dry solids deposited, or about 2.5 feet (0.7 m) per year (at the present tailings disposal area). A cover composed of these substances would be overlaid periodically by new tailings, requiring frequent reapplication to maintain its effectiveness.

The only viable alternatives proposed by the applicant for dust control during mill operation are 1) wetting the beach areas by control of tailings discharge, 2) wetting the beach areas by sprinkling, and 3) applying chemical crusting agents (Ref. 1, Sec. 3.1, p. 3.0-1).

The planned addition of more tailings transport lines and multi-spigoting (Ref. 1, Sec. 3.1.1, p. 3.0-2) could serve to wet as large an area of the pond surface as possible. However, efforts to position the pond surface to minimize the risk of dam failure would take precedence over wetting the beach, with the result that much of the beach could dry out enough to permit blowing of the tailings. Furthermore, when wetting is being attempted, the tailings discharge will tend to channel itself, again failing to achieve the goal of wetting the entire beach area.

A sprinkler system suitable for use with decant water would require high-trajectory sprinkler heads; hence, the water streams would be susceptible to dispersion by wind. During high winds the sprinkler system would have to be shut down, and the beaches could dry out, allowing blowing to occur.

Low-trajectory sprinkler heads would require the use of fresh water, which would increase the hydrostatic head on the pond and therefore increase seepage, and could interfere with the function of the pond (evaporating the water from the tailings material). With either the high- or the low-trajectory sprinkler heads, the water will tend to channel itself, reducing its effectiveness in controlling blowing. Drip irrigation may reduce channelling of the irrigation water, but the applicant reports that such systems are inefficient for complete areal coverage (Ref. 1, Sec. 3.1.3, p. 3.0-4). Some provision for raising the drip irrigation system as the tailings surface elevation increases would be required.

Treatment of the beach areas with a chemical crusting agent would solve the problems of incomplete coverage associated with wetting. Unlike relatively permanent physical cover materials, the chemical agent can be applied as frequently as required with a minimal disruption of pond operation. However, the chemical stabilizer could enter the pond water and be recycled to the mill circuit, where it could possibly interfere with flotation or solvent-extraction circuits (Ref. 1, Sec. 3.1.4, p.3.0-6). Although the operating costs for chemical stabilizers would be significantly higher than for irrigation, the initial capital expense (for a Rain Train sprinkler device) is considerably less than for an irrigation system.

The staff concludes that effective dust control can be achieved by any of the alternatives discussed above, subject only to limitations imposed by prevailing meteorological conditions and operational problems arising from their implementation. Control of blowing tailings will be a license condition.

The dose rate from gamma radiation at the surface of the uncovered slime section of the tailings is estimated to be 16 rem/yr. The reduction in gamma radiation that would result after an application of overburden depends on the degree of compaction and mass stopping power of the overburden. The staff has estimated that 2.6 feet (0.8 m) of packed earth will reduce the dose rate from 16 rem/yr to the background level (from terrestrial source) of 40 mrem/yr. For the non-slime section of the tailings, a packed-earth cover of 1.7 feet (0.5 m) would be needed for dose-rate reduction to background level. These shielding requirements are adequately met by the tailings management plans contained in Alternative 1.

The radon flux from the uncovered surface of the slimes section of the tailings is estimated to be 1300 pCi/sec-m^2. The slimes section will be covered with five feet (1.5 m) of non-slime material, from the surface of which the emanation rate is estimated to be 165 pCi/sec-m^2. The covering scheme provided by Alternative 1 for the slimes section of the tailings is expected to reduce the radon-emenation rate to approximately 7.1 pCi/m^2-sec. This is less than 4.7 times the expected background radon emanation rate of 1.6 pCi/m^2-sec in the Atlas area. For the non-slimes section, the covering is expected to reduce the radon emanation rate to less than 5.8 times that of background. The staff estimates that for the slimes section of the tailings, a 60% increase in the thickness of the sand and a 35% increase in the thickness of the clay would reduce radon emanation to less than twice background. For the non-slimes section, an 80% increase in the thickness of the sand and a 75% increase in the thickness of the clay would bring the emanation rate to less than twice background. The thicknesses of the layers would then be (a) for slimes areas covered by five feet of non-slimes, topsoil - 1 foot, local silty fine material - 4.3 feet, clay - 2.0 feet, and (b) for non-slimes areas, topsoil - 1 foot, local silty fine material - 4 feet, and clay - 1.75 feet.

The applicant's conslultant (Dames & Moore) has used a value of 3.68 pCi/m^2-sec for the background Rn-222 emanation rate. This was obtained from a soil sample taken less than 0.5 mile from the mill in March 1973. Because the mill had been in operation for over 15 years when the soil sample was taken, Rn-222 emanation estimated from this sample would represent technologically enhanced background rather than pre-operational background. From the nature of the soil in the Atlas area, the staff estimates a value of 1.6 pCi/m^2-sec to be the pre-operational background and this value was used in calculating the cover thickness which will be required by a license condition.

An environmental monitoring program will be in effect during mill operation. Data from this program will be used to obtain a better value of the background radon emanation rate in the Atlas area. Based on this measured background value, the applicant may be required to adjust the thicknesses of the tailings covering layers to meet the objective of less than twice background radon emanation rate from the reclaimed tailings area.

The estimated cost of Alternative 1 is $3.3 million (1977 dollars) for the abandonment activities described with thicknesses proposed by the applicant. No costs are included for normal pond operation, or for the increased cover thicknesses calculated above.

Additional costs will be the loss of the tailings retention site for other uses since it will likely be permanently restricted. Minor costs will be the temporary noise and dust generated by the cover construction activities and the temporary loss of an estimated 80 acres of grazing land in the clay borrow area.

Benefits would be that wind and water erosion of the tailings would be controlled, there would be a reduction in gamma radiation and radon release to specified levels, and the appearance of the pile would be enhanced. Future recovery of minerals in the tailings would be relatively easy.

Alternative 2

Alternative 2 is similar to Alternative 1 except that a gravel shell would be used instead of vegetative stabilization. For Alternative 2, the tailings would be covered with clay imported from off site, overlain in turn by silty fine sand obtained from the site and site vicinity, and by durable sandy gravel. The gravel thicknesses would be four inches on relatively flat parts of the pile and one foot on slopes. The thickness of the silty fine sand proposed by the applicant would be 2.8 feet (over non-slimes) or 5.4 feet (over slimes covered with five feet of non-slimes). The clay thickness proposed by the applicant would be 1.0 foot thick in non-slimes areas and 1.5 feet thick in areas where five feet of non-slimes overlie slimes. These thicknesses would have to be increased based onthe more conservative background radon flux used by the staff if alternative II were chosen.

The estimated cost of the stabilization activities for Option 2 is estimated at $3.6 million (1977 dollars). The site would be unavailable for other uses following stabilization. The other minor costs discussed under Alternative 1 would be applicable to Alternative 2.

Benefits derived from Alternative 2 with cover thicknesses increased to meet the twice background objective would be similar to Alternative 1 except that the pile would look out of place with the surrounding area because of the gray gravel cover, and long-term seepage would be greater with Alternative 2, as the gravel would serve to reduce evaporation and to increase percolation of rainwater into the tailings. The gravel covering would effectively attenuate the winds, and the staff believes that the long-term risk of tailings dispersion by blowing would be negligible. Comparable protection from disruption by natural forces would result from this alternative.

Alternative 3

Alternative 3 is similar to Alternative 1 except that no imported clay liner is used. The tailings would be covered with 6.4 feet (over non-slimes) or 9.0 feet (over slimes covered with five feet of non-slimes) of silty fine sand, in turn covered with one foot of topsoil. The pile would be revegetated with appropriate plant species.

There would be no clay liner in this alternative which would allow the percolation of groundwater through the tailings pile. Seepage with this alternative could be excessive, therefore, no detailed radiological review of the thicknesses proposed was completed since the alternative is unacceptable based on the increased seepage risk.

The estimated cost of Alternative 3 is $5.4 million (1977 dollars). The additional costs and the benefits would be nearly the same as for Alternative 1.

Alternative 4

Alternative 4 would utilize an artificial liner (PVC plastic) to control radon emanation and to prevent groundwater percolation through the stabilized tailings pile. The liner would be held in place with a soil cover of 1.5 to 2.3 feet which would then be revegetated with appropriate plant species.

The major hazards involved in this alternative are the limited life of the artificial liner, probably in the range of 20 years to a few hundred years, and the risk of the soil cover slipping off or being eroded away. There are additional problems of root penetration of the plastic liner or accelerated liner deterioration due to exposure to the chemicals in the tailings.

While the short term benefits of Alternative 4 would meet the desired objectives, the long term viability of this system is questionable.

The cost of Alternative 4 is estimated by the applicant at $3.4 million (1977 dollars).

Alternative 5

Alternative 5, as proposed by the applicant, consists of continued operation of the existing tailings retention area in much the same manner as in the past. Following mill shutdown, the tailings would be transported to Site "A"[1] for permanent storage. This site is a box canyon located about 11 km northwest of the present site.

Blowing of tailings to unrestricted areas during normal operations would be prevented by the use of chemical crusting agents. The entire tailings area would be fenced.

Transport and reclamation of the tailings would begin as soon as the tailings have reached sifficient dryness (probably within two years following mill shutdown). The tailings and any contaminated soil underlying the tailings would be transported by truck to Site "A". Site "A" would be fenced. Site "A" would not be lined to prevent seepage since the tailings would be unsaturated and the clay cap would preclude future leaching of the tailings by infiltrating rainwater. The slimes portion of the tailings would be buried deeply by non-slimes. The tailings placed at Site "A" would be covered with one foot of clay imported from Site "B", overlain in turn by 2.3 feet of silty fine sand from the vicinity and one foot of topsoil. The area would be revegetated with appropriate plant species.

The estimated cost for transporting the tailings contaminated soil (assumed to be two feet thick under the existing pile) and of reclamation of the tailings at Site "A" is $44.0 million (1977 dollars). Associated costs are the loss of Site "A" for other uses since the area will probably be restricted; the high energy consumption associated with transportation of the tailings and the temporary noise,dust and congestion created by the transportation and construction activities. There would be little change in total seepage compared with Alternative 1.

Benefits would include a more remote location, possibly reduced risk of disruption and dispersion of the tailings, gamma radiation and radon emanation reduced to specified levels and the control of wind erosion of the tailings. Future recovery of mineral values in the tailings would be relatively easy. The present Atlas site could become available for other uses.

Alternative 6

Alternative 6 is similar to Alternative 5 except the tailings would be moved to Site "B"[1] for permanent storage after mill shutdown. Transport of the tailings and reclamation of the site would be the same as described for Alternative 5 except the tailings would be covered with four feet of clay.

Site "B" is an area of low rolling hills with an abundance of clay available, located about 24 km northwest of the present site.

The estimated cost for Alternative 6 is $52.0 million (1977 dollars). Associated costs and benefits are similar to those described for Alternative 5. Seepage potential would be reduced since the site overlies the Mancos Shale.

Alternative 7

Alternative 7 consists of establishing a new tailings impoundment at Site "A". New tailings and existing tailings would be transported to Site "A" by pipeline over the 15-year life of the mill.

The impoundment area would be prepared by constructing a water retention type dam across the north face of the area. The impoundment area would be lined with clay obtained from Site "B". The entire area would be fenced. Tailings would be transported to the site from the Atlas mill by a 10.5 mile pipeline approximately following U.S. Highway Route 160 in Moab Canyon. The existing tailings would be hydraulically mined over a period of 15 years and would be added to the tailings produced by the mill, for transport to Site "A". Excess water at Site "A" would be decanted and returned to the mill by pipeline. Blowing of tailings at both ponds would be controlled by the use of chemical crusting agents during operations.

Reclamation of the old tailings retention area would begin as soon as all old tailings have been removed. Contaminated soil underlying the pond area would be excavated and trucked to Site "A". The old tailings area would be contoured and revegetated with appropriate plant species.

Reclamation of the new tailings area at Site "A" would begin when it has reached sufficient dryness (probably within two years of mill shutdown). The tailings would be shaped and contoured and then covered with a clay liner, silty sand, and topsoil with a thickness similar to those described for Alternative 1. The area would be revegetated with appropriate plant species.

The estimated cost of Alternative 7 is $18.3 million (1977 dollars) which includes an estimated $2.7 million for dam construction and pond lining. Associated costs would be the loss of Site "A" for other uses, and the energy consumption associated with the movement of the tailings and cover materials. The possibility of minor releases of tailings would be higher than trucked tailings due to the vulnerability of 10.5 miles of pipeline and the slurry form of the tailings.

Benefits include a probable reduction in seepage since Site "A" would be lined, whereas the old tailings pond is unlined. Other benefits are the same as described for Alternative 5.

Alternative 8

Alternative 8 is similar to Alternative 7 except that Alternative 8 involves movement of the tailings to Site "B" instead of Site "A" for permanent storage. Reclamation would be similar except that the tailings would be covered by local clay soil.

The estimated cost of Alternative 8 is $21.7 million (1977 dollars) which includes an estimated $3.0 million for dam construction and pond lining. Associated costs and benefits are similar to those described for Alternative 7.

Alternative 9

Alternative 9 consists of continued operation of the existing tailings retention area in much the same manner as in the past. Following mill shutdown the tailings would be moved to the existing Rio Algom tailings area for permanent storage. Blowing of tailings during normal operations would be prevented by the use of sprinklers. The entire tailings area would be fenced.

Transport and reclamation of the tailings would begin as soon as the tailings had reached sufficient dryness (probably within two years following mill shutdown). The tailings and any contaminated soil underlying the tailings would be transported to the Rio Algom site by truck. The new disposal site would be fenced. The new site would not be lined to prevent seepage since the tailings would not be saturated and the cap would prevent leaching of the tailings by rainwater. The slimes portion of the tailings would be buried deeply by the non-slimes portion. The tailings would then be covered by four feet of clayey alluvial material obtained from the vicinity. The area would be revegetated with appropriate plant species.

The estimated cost for transporting the tailings and contaminated soil and reclamation of the tailings area is $72.0 million (1977 dollars). Associated costs would include the loss of the new site for other uses since it will probably be restricted, the higher energy consumption associated with transportation of the tailings, temporary noise, dust and congestion created by the transportation and construction activities. There would be little change in seepage compared with Alternative 1.

Benefits would include a more remote location than the present site, and centralization of the tailings. Other benefits would be similar to those described in Alternative 5.

Alternative 10

Alternative 10 is similar to Alternative 5 and Alternative 6 except that tailings would be moved to Site "A" or "B" by a conveyor system and the railroad. Tailings would be removed from the existing tailings area following mill shutdown by use of an automatic scraper type reclaimer. Material from the reclaimer would be deposited upon a conveyor which would transport the tailings to the Rio Grande Railroad west of the site. The railroad would transport the tailings to either Site "A" or "B", for which a spur track would be constructed. A conveyor system would be used to distribute the tailings at the disposal site. Reclamation of the disposal site would be as described for Alternative 5 and 6. No commitment for use of the railroad has been made by the Rio Grande at this time.

The estimated cost for Alternative 10 is $31.9 million or $31.5 million for transport to either Site "A" or Site "B", respectively. Because of the short haul involved, railroad transportation cost (exclusive of spur construction cost) is approximately the same for both sites. Therefore, the abandonment and spur construction costs are the primary items which account for the difference in the cost for the two sites.

Benefits would be the same as those described under Alternative 5 and 6.

10.3.3 Evaluation of Alternatives

Alternative 1 is the option proposed by the applicant for tailings management at the Atlas Mill. With increased cover thicknesses as indicated by the staff calculations of paragraph 10.3.2 this option is acceptable. The composition of cover materials proposed as well as the thicknesses finally used will be subject to adjustment based on the results of the applicant's ongoing monitoring programs and on the NRC confirmatory research programs dealing with erosion and radon diffusion through various materials. Alternative 1 as modified will meet the objective for radon flux reduction and surface gamma radiation reduction. The percolation of ground water through the tailings pile and subsequent seepage from the pile will be minimized by the clay liner which will act as a perching layer to divert precipitation off the tailings area. The objective for minimal long term maintenance and monitoring will be met by recontouring and vegetative stabilization of the pile.

Alternative 2 if modified to staff calculated cover thicknesses would meet the tailings management objectives nearly as well as Alternative 1. The gravel cover as proposed by the applicant would tend to reduce evaporation and increase percolation of rain water into the tailings pile with attendant increased seepage from the pile. Additionally, as was clearly evident from the staff's aerial survey of the area, a 200 acre mound of grey gravel would be the most noticeable landmark for 25 miles, in an area noted for its panoramic views.

Alternative 3 is roughly comparable to Alternative 1 but would allow rain water to percolate unimpeded through the tailings pile and is therefore unacceptable.

Alternative 4 is unacceptable due to the limited life of the PVC plastic liner, the risk of cover erosion or slippage, the risk of root penetration of the plastic and the uncertainties associated with ground water flows beneath the cover.

Alternatives 5 through 10 represent a group of tailings movement alternatives, and will be addressed as a group.

The applicant proposed two alternative sites for tailings disposal located about 11 mk and 24 km from the present site. A staff visit to the site was directed to location of any other possible sites for tailings disposal. The site visit consisted of consultation with personnel of the Utah State Division of Oil, Gas and Mining, the Denver regional Environmental Protection Agency office, and discussions with the personnel of the regional office of Bureau of Land Management. A tailings disposal alternative review was conducted, with these agencies, of the geology and topography of the area. The first review utilized maps, aerial photographs, well logs and other available documentation. This was followed by a comprehensive aerial survey of the area within 25 miles of the existing mill site, and a ground survey of the area near roads or in some cases using off road vehicles.

During the staff visit, the land was surveyed for disposal sites without regard for land ownership or ease of access. The only criteria used were availability of a 200 acre site offering environmental advantages over the present site.

The two sites proposed by the applicant were found to be the only sites available within a 25 mile radius of the mill which offer environmental benefits equal to or better than the present site.

Most of the region is composed of a well fractured red sandstone with permeability much higher than the present site or Sites A and B. In the southerly direction, the valley is usable for crops and is generally inhabited. In the western direction, the topography is uniformly composed of the red sandstone with deeply eroded washes throughout. To the east, the Arches National Park is made up of the same red sandstone with clear evidence of massive erosion toward the river. During the site visit, there were unusually severe rains for several days with resulting flash flooding throughout the area. While the flooding at the present site was confined to Moab Wash, the area at Sites A and B was flooded extensively, with the road to Site A damaged and the road to Site B washed away and passable only with off road vehicles.

Site A consists of a box canyon with alluvial soils similar to those under the existing tailings pile. While it offers some advantage by being more distant from Moab, the drainage area around it is greater than that above the present pond, and protection from flooding of the kind encountered during the site visit would be more difficult than at the present site.

Site B is actually a multitude of similar sites, a plain of clayey hills underlain by a formation of Mancos Shale. While some reduction in seepage would be realized, the wide spread flooding of this low lying plain would seem to preclude its use for long term above grade storage of tailings.

During the aerial survey, it became apparent that rail transport of the existing tailings to Sites A or B might be a viable alternative, and the applicant provided Alternative 10 which is an estimate of rail transport costs for tailings movement alternatives.

10.3.4 Alternatives Considered and Rejected

Due to the location of the present site on the banks of the Colorado River, the staff conducted a detailed review of not only the alternatives proposed by the applicant, but of any alternative evenly remotely feasible. Table 10.1 lists some of the alternatives considered and rejected.

TABLE 10.1

Tailings Management Alternatives Rejected

Alternative	Reason for Rejection
Raise pH of slurry with lime; treat with barium chloride to precipitate radium and thorium.	Majority of tailings are presently in place.
Segregate (chemically) the toxic components of the tailings and dispose of these small quantities as low-level waste. Treat "clean" tailings as overburden.	Technology not developed to implement alternative.
Precipitate radioactive and toxic elements to bottom of the tailings pond and consider top of tailings as cover.	Technology not developed (would require a selectively permeable bottom liner).
Install drains below pond to collect and discharge to a local waterway.	Technology not available to allow seepage water treatment sufficient to attain water that is environmentally and legally acceptable for release.
Filter the tailings; cake the sands and transport to a landfill.	Filters of sufficient size and efficiency are not commercially available. Majority of tailings are already in place.
Return of the tailings to the Atlas mines in the Big Indian District.	Staff visit clearly showed massive caving of the stopes of the abandoned mines, the disposal volume remaining is only a few percent of the space needed.
Disposal of the tailings in the cavities left by solution mining of salt or potash in the vicinity.	Cavities formed by solution mining close due to salt flow, and there is no method to control tailings movement once emplaced in an active solution mining region. Precludes future recovery of mineral values.
Excavation of a below grade pit for tailings disposal at the present site.	Insufficient area available on the site. Natural water table lies very close to the surface.
Mixing tailings with cement or asphalt before disposal.	Most tailings are already in place. Large amounts of cement and asphalt required, and future recovery of mineral values precluded.

10.4 ALTERNATIVE ENERGY SOURCES

10.4.1 Fossil and Nuclear Fuels

The use of uranium to fuel reactors for generating electric power is relatively new historically. Coal was the first fuel used in quantity for electrical power generation. Coal use was reduced because of the ready availability and low price of oil and natural gas, which are cleaner-burning than coal and easier to use. Uranium fuel is even cleaner (chemically) than oil or gas, and at present is less expensive, on a thermal basis, than all other fuels used to generate electric power. The following discussion concerns the relative availability of fuels for power generation over the next 10 to 15 years, since availability will be the key factor in the choice of fuel to be used.

Table 10.2 shows the disparity between availability and usage of energy resources in the U.S. Although these data are for 1974 (final figures for 1975 are not yet available), estimates for 1975 indicate little difference. Gas usage in 1975 decreased slightly ($\sim$1%); oil, coal, and nuclear usage increased slightly.[7]

Table 10.2. Reserves and Current Consumption of Energy Sources[5]

	Percent of Proven U. S. Energy Reserves Economically Recoverable with Existing Technology (1974)	Percent of Total U. S. Energy Consumption Contributed by Each Energy Resource (1974)
Coal	90	18
Oil	3	46
Gas	4	30
Nuclear	3	2
Other	0	4

In 1975, the U. S. consumed about 71 q of energy (1 q = 10^{15} Btu); of this total, 20 q consisted of electric energy. An estimated 8.6% of this electric energy was generated using nuclear fuels, but within ten years the precentage is expected to increase to 26%.

Coal was used for producing 59% of the electric energy generated by combustion of fossil fuel in 1975; the percentages for oil and gas were 20 and 21, respectively. Use of oil and gas to generate electric power has decreased about ten percent over the last three years, a reflection of high oil prices and gas unavailability.[5]

Current and projected requirements for electric energy (1975-1985) and relative changes in resources used for generation, as estimated in "Project Independence,"[6] are shown in Table 10.3. All information available to date indicates that coal and uranium must be used to generate an increasing share of future U. S. energy needs, because of decreasing supplies of oil and gas available for electric power generation. The U. S. does not have sufficient oil and gas reserves to ensure a long-run supply, but coal and uranium resources are adequate for foreseeable needs. Currently rising prices for oil and gas are a reflection of increasing competition for these two resources which will be severely depleted in the next few decades.

Expanding industrial capacity for increasing coal production to meet projected requirements must occur in the next decade (total requirement is 1040 million tons in 1985 vs. 603 million tons in 1974). The major expansion of coal production will likely be in the West (from 92 million tons in 1974 to 380 million tons in 1985) because of the low sulfur (low air pollutant) content of most western coals. The potential for environmental damage (due to disturbance of generally fragile ecosystems) in the western U. S. will be increased. Since the major markets for the coal produced are located hundreds of miles from the mines, transportation costs will be high,

Table 10.3. Estimated Relative Changes in Resources to be Used for Generation of Projected Energy Requirements[6]

	Percent of Thermal Energy Required in Year:			
Fuel Resource Used	1970[a]	1974[b]	1980[b]	1985[c]
Coal	45	45	45	46[c]
Oil and gas	38	34	25	16
Nuclear	2	4[d]	17	26
Hydro, waste, etc.	15	17	13	12
Total q's of energy required	15.6	20	25.5	34

[a]Actual.

[b]Estimated (Ref. 5).

[c]Coal usage must increase 77% by 1985 to attain this level.

[d]Uranium fueled reactors furnished 9.9% of the total U. S. production in January 1976.

as will the environmental impacts associated with transportation systems. Transportation costs for bringing western coal to the eastern U. S. currently accounts for the major portion of the market price.

For a given thermal content, transport facilities for U_3O_8 are minimal compared to those for coal because of the much higher energy content of uranium fuel. Approximately 250 tons of U_3O_8 per year are required for a 1000-MW nuclear plant operating at a plant factor of 80%. Annual western coal requirements for an equivalent 1000-MW coal plant would be more than three million tons, or the load capacity of at least one unit-train (100 cars of 100 tons each) per day of plant operation.

The evidence available at this time indicates that, of the resources currently used in electric power generating stations (coal, uranium, oil, gas, and hydro), only coal and uranium have the potential for increasing long-range reliability in domestic energy production. Because of the time lag between initial extraction and the consumption of the resource for energy production (3-5 years from mine to generation plant for uranium and coal; 5-7 years for construction of a coal generating plant and 7-10 years for construction of a nuclear generating plant), the exploitation of both coal and uranium resources must be integrated with contemporary energy needs. Neither the coal nor uranium producing industries are considered capable of singly supporting the energy requirements projected over the next few decades; major expansion of both industries will be required to fill projected needs.

The determination of availability of uranium in large enough quantities to fuel the projected nuclear generating capacity (for 1985) is currently a matter of study.[7] Results of those studies are given below.

Estimates presented in the "National Energy Outlook"[5] indicate that 140,000 to 150,000 MWe of nuclear generating capacity will be needed to supply 26% of the total electrical energy used in 1985. The first "Project Independence"[6] report indicated that nuclear capacity could increase to more than 200,000 MWe by 1985. A more recent and lower estimate resulted from lower projections of electricity demand, financial problems experienced by utilities, uncertainty about government policy, and continued siting and licensing problems. The more recent projections of uranium requirements are given in Table 10.4.

Table 10.4. Uranium Requirements[5]

	Lifetime U_3O_8 Requirements, tons	
MWe Operating by 1985	at P.F. of 0.8[a]	at P.F. of 0.6
142,000	960,000	704,000

[a]P.F. = Plant factor, or capacity factor.

Known reserves of uranium (as U_3O_8), as of January 1976, were an estimated 640,000 tons, as compared to 600,000 tons estimated in January 1975.[8] These reserves could be mined and milled at a cost of $30/lb of U_3O_8 produced. The price of U_3O_8 in April of 1976 was $40/lb for delivery in 1976, and $48/lb for delivery in 1980.

ERDA has estimated total U. S. uranium resources as shown in Table 10.5.[8] The total of all variously known categories of uranium resources is equivalent to 3,560,000 tons of U_3O_8. Reserves are in known deposits; drilling and sampling have established the existence of these

Table 10.5. U. S. Uranium Resources[8]

	Tons U_3O_8			
		Resources		
Cost, $/lb U_3O_8	Reserves	Probable	Possible	Speculative
$30	640,000	1,060,000	1,270,000	590,000

deposits beyond reasonable doubt. Probable resources have not been drilled and sampled as extensively as reserves. The speculative and possible resource categories have been estimated by inference from geologic evidence and limited sampling.

Historically, resources of uncertain potential have become established reserves at an average rate of seven percent per year since 1955.[6] If this rate were to persist over the next decade, total reserves would exceed requirements (1,250,000 tons of reserves vs. a maximum 960,000 tons required for lifetime nuclear generating capacity rated at 142,000 MWe) by about 300,000 tons. Assuming no transfer of possible resources into the probable category, probable resources would still contain 450,000 tons.

10.4.2 Solar, Geothermal, and Synthetic Fuels

Estimates reported in the "National Energy Outlook"[5] indicate that solar and geothermal sources will each supply about one percent of U. S. energy requirements by 1985 and about two percent by 1990. Supplies of synthetic gas and oil derived from coal will probably not exceed one percent of U. S. energy requirements as of year 1990. These projections are based on many considerations. The technology exists in all cases, but not in a proven, commercially viable manner. The potential for proving these technologies on a commercial scale is great, but timely development will require a favorable market as well as governmental incentives. A maximum of six percent of projected 1990 energy requirements is expected to be derived from solar, geothermal, and synthetic fuel resources combined.

10.4.3 Byproduct Uranium

Uranium reserves recoverable as a byproduct of phosphate fertilizer and copper production are expected to increase from 90,000 tons (U_3O_8) in 1974 to 140,000 tons in 1976. These reserves are in addition to the 640,000 tons available from conventional mining and milling sources.

Quoting from Reference 7 (p. 106):

> "Like all byproducts commodities, byproduct uranium is entirely dependent upon production of the primary commodity, is limited in amount by the level of production of the primary commodity, and is unresponsive to the demand for uramium. Byproduct uranium could be obtained from the mining of phosphate, copper and lignite.
>
> "Much phosphate is treated with sulfuric acid to produce fertilizer and goes through a phosphoric acid step. Uranium in the phosphate can be recovered from the phosphoric acid. ... It has been estimated that about 2,500 ST U_3O_8 per year could be recovered from Florida phosphate mined for fertilizer. The Bureau of Mines studied the sulfuric acid leaching of low grade dumps at 14 porphyry copper mines and concluded that about 750 ST U_3O_8 per year could be recovered. This would be recovered from rocks whose uranium content ranges from 1 to 12 ppm.
>
> It was also thought that other posphyry copper deposits might also be possible sources of byproduct uranium.
>
> "This possible byproduct uranium totals 3,250 ST U_3O_8 per year which is only slightly less than the initial annual production planned for the Rossing deposit in South West Africa.
>
> "Another source of byproduct uranium could be mine-mouth electrical generating plants that burn uranium-bearing lignite as fuel. The uranium is concentrated in the ash. Some lignite contains as much as 0.30 percent U_3O_8. Bieniewski estimates that about 1500 ST of U_3O_8 is contained in about 500,000 ST of high grade lignite. More recently reserves in lignite were estimated to be less than 5,000 ST of U_3O_8 and resources to be about 50,000 ST. Low-Btu lignites seem to be richest in uranium. Good-quality coals usually contain less than 0.001 percent U_3O_8. If lignite is burned at too high a temperature the uranium enters the ash in a form that is not easily leachable and for which an economic recovery system has not yet been developed."

10.4.4 Energy Conservation

The NRC staff has examined available information concerning the potential reduction in energy usage that could be achieved by 1985 and concludes that incremental savings in *total* energy consumption could be achieved in all major consumption sectors: residential, commercial, industrial, and transportation. Actions which improve the thermal efficiency of automobiles, homes, and office buildings would have the greatest conserving effect. However, in the case of electrical energy, demand is expected to increase (during the next decade) at a rate about twice as great as that for total energy.[5] It will be more difficult to conserve electrical energy since it will probably be a viable alternative for oil and gas use in residential heating and for some industrial applications. Conservation will not materially change the need for increased dependence on coal and uranium as fuels for generating electric power during the next decade.

10.5 ALTERNATIVE OF NO RELICENSING ACTION ON EXISTING MILL

10.5.1 Economic Impact

Among the alternative actions available to the NRC is the denial of a source material license to the applicant. Classifications of source materials are discussed in 10 CFR Part 40; these classifications, based on Section 62 of the Atomic Energy Act of 1954, specifically exempt "unbeneficiated ore" from control. Under these regulations Atlas Mills could not process the ore, should the NRC deny the source material license. Exercise by the NRC of this option would thus leave the applicant with two possible courses of action: (a) temporarily decommission the mill while attempting to remove the objections that led to the denial of the license; or (b) abandon the project. Alternative (a) is essentially the applicant's proposal (merely shifted in time), which is the subject of this statement (although shutdown, maintenance, and startup costs would increase economic impacts). Alternative (b), therefore, is the only alternative discussed here.

If the applicant were not granted a source material license, the uranium concentrate it intends to produce would not become available for use as fuel in nuclear reactors in as timely a manner. Appendix B discusses the need and timeliness of the project and the basis for the NRC evaluation.

The U_3O_8 produced by the Atlas mill will be used as fuel in nuclear reactors which are either operating or under construction (in 1976). These reactors will produce electric power for sale to U. S. consumers. Lack of fuel would require those reactors short of fuel to reduce their output, and could conceivably result in some reactor shutdowns.

10.5.2 Social Impact

Because the Atlas mill is a key element in the economic structure of the community (Sec. 4.8.5), the non-relicensing of the mill would have repercussions on the economy and social structure of the area.

To determine these impacts, a computer program, the Utah Process Economic and Demographic Impact (UPED) Model,* was employed to look at three scenarios: *baseline* (i.e., normal growth projections, including mill operation); *mill only* (i.e., closure of the mill with no major impact to related industries); *mill plus* (i.e., shutdown of the mill with concomitant impacts on related industries such as trucking and mining). The model examines impacts to the year 1990 in five-year intervals. The model is slightly disadvantageous in that it analyzes regional impacts to the Southwestern Multi-County District (Grand, San Juan, Emery, and Carbon Counties) rather than isolating distinct impacts to Moab and Grand County, but this approach does present a realistic description of any impacts, due to the interrelatedness of industry and the number of in-migrating workers to Grand County.

Table 10.6 summarizes the economic and demographic impacts under the three scenarios. Even though the scenario projecting the closing of the mill (i.e., mill only) hypothesizes the unemployment of only the 161 mill workers, the impacts to the community have been projected to be far greater, because of the ripple effect into other employment sectors (Table 10.7). By 1980, 273 jobs would be lost in the area. Without some intervention, in the form of governmental assistance or new job opportunities, the number of lost jobs would continue to grow slightly over the next ten years.

Those projections in the *mill only* scenario can be considered the minimum projections. It is more probable that non-relicensing of the mill will directly affect the mining and transportation of uranium and related service areas. While some of these enterprises may transfer their association to the Rio Algom mill (25 air miles SE), it can be expected that some will not be able to make this change. Therefore, the second scenario of *mill plus* can be considered to be the maximum impact caused by the closing of the Atlas mill.

The impact to the area under the *mill plus* scenario results in the loss of 284 jobs in the mining and milling operations, with another 194 positions being terminated by 1980. As in the *mill plus* scenario, the area is projected as being unable to adjust to this degree of unemployment, resulting in a projected mass out-migration from the area. With an estimated population

*Prepared for the staff by Rho Associates, Incorporated, of Salt Lake City, Utah, as calibrated for the Utah Office of the State Planning Coordinator, November 1976.

Table 10.6. Projections of Economic and Demographic Impacts of Non-Relicensing[a]

Scenario	1980 Total Population	1980 Total Employment	1980 Total Households	1985 Total Population	1985 Total Employment	1985 Total Households	1990 Total Population	1990 Total Employment	1990 Total Households
Baseline Projection	48,946	19,947	15,124	55,561	22,849	17,751	58,227	24,146	19,058
Mill Only	48,326	19,675	14,952	54,845	22,590	17,536	57,475	23,827	18,828
Impact	-621	-273	-173	-716	-304	-215	-751	-319	-231
Mill Plus	47,859	19,470	14,822	54,307	22,361	17,374	56,911	23,587	18,655
Impact	-1,087	-478	-303	-1,254	-533	-377	-1,316	-559	-404

[a]Source: Rho Associates, Inc., using UPED Model.

Table 10.7. Basic Employment Assumption Summary for the Southeastern Multi-County District Following Non-Relicensing[a,b]

Broad Industrial Sector	Baseline Projection			Mill Only Impact[c]			Mill Plus Impact[c]		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
Agriculture, Forestry, and Fisheries	683	652	610	-1	-1	-1	-2	-2	-2
Mining	4392	5098	5294	-162	-162	-162	-284	-284	-284
Contract Construction	1955	1846	1690	-5	-8	-9	-9	-13	-16
Manufacturing	850	978	1009	-3	-3	-3	-5	-6	-6
Transportation, Communication, and Utilities	1450	1683	1750	-6	-8	-8	-11	-13	-14
Wholesale and Retail Trade	3492	4139	4432	-30	-39	-42	-53	-69	-74
Finance, Insurance, and Real Estate	422	543	635	-5	-7	-8	-8	-12	-14
Services	2847	3467	3815	-25	-33	-37	-44	-58	-66
Government	3856	4489	4912	-35	-43	-48	-62	-75	-85
Total	19,947	22,895	24,147	-272	-304	-318	-478	-532	-561

[a]Source: Rho Associates, Inc. using UPED Model.

[b]Projections include migration from the area.

[c]"Impact" denotes the difference between projected activity levels in the named projection and the Baseline Projection.

of between 5500 and 7000 over the next two decades (Sec. 2.4.2), a decrease in population of between 600 to 1300 would severely impact Grand County.

The earliest out-migrants are projected to be primarily between the ages of 20 to 40 and under age 14. These represent young, married persons with children, who are often the first to be affected by a work layoff and who must often relocate to find work. In this case, an immediate impact would be felt by the community's school system. Because of the many educational facilities available in Moab (see Sec. 2.4.4.1), loss of these children would be felt at the local level as well as State level (Table 10.8). Also, the social make-up of the community would be altered because the area would be primarily composed of people over the age of 40.

Table 10.8. Impact to School-Age Population and Teaching Staff Under Two Scenarios

	Mill Only Impact			Mill Plus Impact		
	1980	1985	1990	1980	1985	1990
Primary	-86	-77	-113	-150	-135	-198
Secondary-Jr. High School	-26	-42	-28	-45	-73	-50
Secondary-Sr. High School	-35	-26	-40	-62	-46	-71
Higher Education Undergraduate	-75	-42	-43	-132	-73	-75
Higher Education Graduate	-171	-167	-80	-299	-293	-140
Total	-393	-354	-304	-688	-620	-534
State School	-1	-1	0	-2	-1	-1
Local School	-12	-12	-14	-20	-21	-25

The applicant has indicated the effects of the loss of local and regional economic benefits that would occur if the Atlas mill were not relicensed. The NRC staff has examined the applicant's tabulations of benefits and costs and made an independent assessment of benefits and costs of the proposed project (see Sec.11), and has concluded that the overall benefit-cost balance is favorable for continuation of the Atlas operations.

References

1. "Tailings Management and Reclamation Alternatives Study for Atlas Minerals Mill at Moab, Utah," Dames & Moore, Revised October 14, 1974.

2. J. E. Pearson, "Natural Environmental Radioactivity from Radon-222," Public Health Service, U. S. Dept. Health, Education and Welfare, 1967.

3. J. E. Weaver, "Prairie Plants and Their Environment," Univ. of Nebraska Press, 1968.

4. Phillips Petroleum Co., "Pasture and Range Plants," 1963.

5. "National Energy Outlook," Federal Energy Administration, February 1976.

6. "Project Independence," Federal Energy Administration, November 1974.

7. "Mineral Resources and the Environment," Supplementary Report: "Reserves and Resources of Uranium in the U. S." National Academy of Sciences, 1975.

8. "Coal Power and Combustion--I, II, III," ERDA 76-94, quarterly reports of Energy Research and Development Administration, April 1976 (latest estimate of U. S. uranium resources.

11. NRC BENEFIT-COST SUMMARY FOR THE ATLAS MILL

11.1 GENERAL

The general need for uranium mills is subsumed in the operation of nuclear power reactors. In reactor licensing evaluations the benefits of the energy produced are weighed against related environmental costs, including a pro-rated share of the environmental costs of the uranium fuel cycle. These incremental impacts in the fuel cycle are justified in terms of the benefits of energy generation. However, it is appropriate to review the specific site-related benefits and costs for an individual fuel-cycle facility such as the Atlas mill.

11.2 QUANTIFIABLE ECONOMIC IMPACTS

Many monetary benefits accrue to the community from the presence of the mill, such as local expenditures of operating funds and the state and local taxes paid by the mill. Against these monetary benefits are monetary costs to the communities involved, such as for new or expanded schools and other community services. It is not possible to arrive at an exact numerical balance between these benefits and costs for any one community unit, or for the mill, because of the ability of the community and possibly the mill to alter the benefits and costs. For example, the community can use various taxing powers to redress any perceived imbalance in favor of the mill. The mill, on the other hand, probably cannot create larger revenues through increased product price to redress any imbalance it suffers through direct or indirect taxation.

11.3 THE BENEFIT-COST SUMMARY

The benefit-cost summary for a fuel cycle facility such as the Atlas mill involves comparing the societal benefit of an assured U_3O_8 supply (ultimately providing energy) against local environmental costs for which there is no directly related compensation. For the Atlas mill these uncompensated environmental costs are basically two: radiological impact and disturbance of the land. The radiological impact of the Atlas mill is low (Sec. 4.7). The disturbance of the land is also a small environmental impact (Secs. 4.2, 4.5, 4.6, and 8). The mill and tailings ponds presently cover approximately 200 acres. Virtually all of the disturbed land will be reclaimed after the mill is decommissioned and, with the possible exception of the tailings burial area, will become available for other uses.

11.4 STAFF ASSESSMENT

The staff concludes that the adverse environmental impacts and costs are such that the use of the mitigative measures suggested by the applicant and the regulatory agencies involved would reduce the short- and long-term adverse impacts associated with the project to acceptable levels.

In considering the energy value of the U_3O_8 produced, minimal radiological impacts, minimal long-term disturbance of land, and mitigable nature of the societal impacts, the staff has concluded that the overall benefit-cost balance for the Atlas mill is favorable, and the indicated action is that of relicensing of the Atlas mill.

APPENDIX A. COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

(Reserved for Comments)

APPENDIX B. BASIS FOR NRC EVALUATION OF THE ATLAS MILL PROPOSAL

THE NUCLEAR FUEL CYCLE

The nuclear "fuel cycle" comprises all the processes involved in the utilization of uranium as a source of energy for the generation of electrical power.

The nuclear fuel cycle consists of several steps:

1. Extraction - removing the ore (uranium) from the ground, separating uranium from the waste, and converting the uranium to a chemically stable oxide (nominally U_3O_8).

2. Conversion - changing the U_3O_8 to a fluoride (UF_6), which is a solid at room temperature but becomes a gas at slightly elevated temperatures, prior to enrichment.

3. Enrichment - concentrating the fissionable isotope (U-235) of uranium from the naturally occurring 0.7% to 2-4% for use in reactors for power generation.

4. Fabrication - converting the enriched uranium fluoride to uranium dioxide (UO_2), forming it into pellets, and encasing the pellets in tubes (rods) that are assembled into fuel bundles for use in power generating reactors.

5. Nuclear Power Generation - using the heat resulting from the fissioning of uranium and plutonium for generating steam for the turbines.

6. Spent Fuel Reprocessing - chemical separation of fissionable and fertile values (U-235, U-238, Pu) from fission products (waste), with concurrent separation of uranium from plutonium.

7. Waste Management - storage of fission products and low-level wastes resulting from reprocessing in a manner that is safe and of no threat to human health or the environment.

This cycle is portrayed in Figure B.1.

Nuclear reactor operation converts about 75% of the fissionable isotope (U-235) into fission products, thereby liberating thermal energy and creating plutonium, another fissionable element, in the process. The remaining quantities of fissionable uranium (U-235) (about the same concentration as exists in natural uranium) and the plutonium are recoverable for reuse in the cycle.

The spent fuel removed from the reactor is stored at the reactor site and later at the reprocessing plant to "cool" the spent fuel. The radioactivity of the fuel is reduced by a factor of about 10 after 150 days storage.

The reprocessing of spent fuel would produce fissionable material that could be used in combination with new (virgin) material obtained by mining and milling. In the absence of reprocessing, all replacement fuel must come from the mining and milling of ore from projects such as Atlas.

USE OF NUCLEAR FUEL IN REACTORS

Two types of reactors are currently used to generate essentially all of the nuclear energy sold in the U.S.: the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). Each reactor type is operated with a fuel management scheme designed to meet the requirements of the utility operator. Different fuel management schemes result in different fuel burnup rates which, along with other design parameters, affect the quantity of residual fissionable materials and the type and amount of radioactive wastes in the spent fuel. These differences, in turn, require specific treatment processes at the reprocessing plant; thus, for maximum overall efficiency, the spent fuel is stored at reactor or reprocessing sites (or both) until a "campaign," using a process related to the individual spent fuels, can be undertaken.

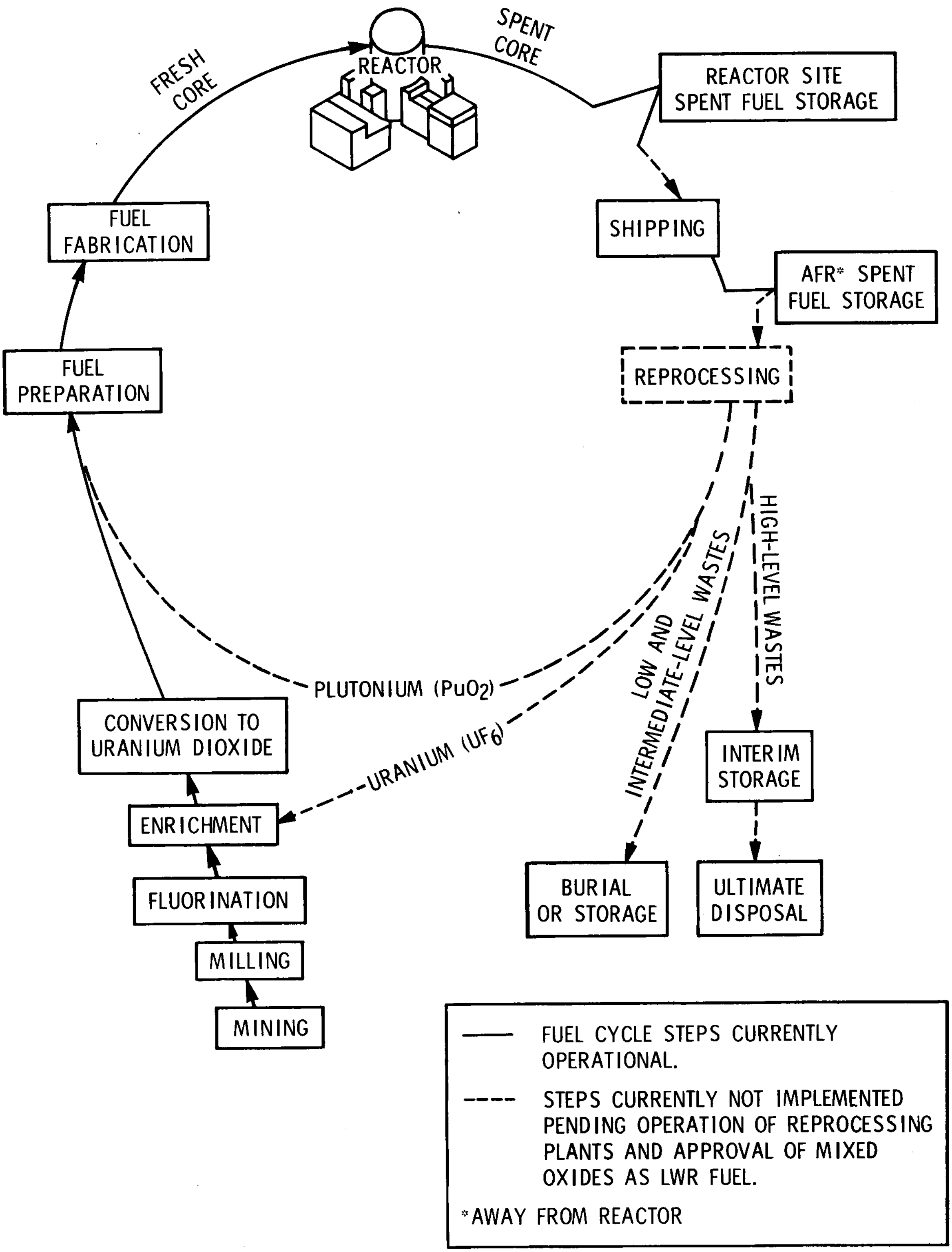


Fig. B.1. The LWR Fuel Cycle.

No commercial reprocessing of spent fuel from power reactors has been carried out since late 1971, and only 244 metric tons of spent fuel (about two reactor core loadings, or six annual reloads) were processed between 1966 and 1971. Since the number of operating reactors has increased tenfold in the last decade and is expected to double by 1980, the need for mining and milling capacity will continue to increase. If reprocessing facilities were available to handle the spent fuel as it is generated, the rate of increase would be more moderate.

The general need for uranium as a fuel for generating electrical power in the U. S. over the next decade has been addressed in Section 1.5, item 5, of this Statement. The specific need for the Atlas mill is outlined below.

Current mill capacity in the U. S. is 26,700 tons of ore per day. These mills operated at 85% of capacity in 1975. Uranium oxide output was approximately 11,500 pounds, equivalent to slightly less than 3 lb U_3O_8 per ton of ore. The Atlas ores have an average U_3O_8 content close to the national average.

Forecasting U_3O_8 requirements over the next decade depends entirely on estimates of the rate at which new nuclear generating capacity is installed. Estimating U_3O_8 requirements for the next five years is somewhat easier because those reactors which will need fuel in that time period are either operating now (1976) or are well along in construction and will operate prior to 1981. Table B.1 shows the cumulative nuclear capacity forecasted for Project Independence by the FEA.[1] (The staff considers this forecast, on the basis of licensing time required, to be reasonable, though somewhat optimistic.[2]) If a vigorously conservative position is taken that no installation of nuclear capacity will occur after 1985, the minimum need for fuel, and hence for U_3O_8, can be computed from the data in Table B.1, on the basis of various assumptions.

Fuel usage in nuclear reactors depends on the power generated, which is conventionally expressed as a decimal or percent, and called "plant factor" (PF) or "capacity factor" (CF). The staff has chosen 0.6 as a minimum plant factor and 0.8 as a maximum to give a range of requirements for U_3O_8 over the next decade.*

Figure B.2 shows projected fuel requirements, assuming a minimum user rate; Figure B.3 shows maximum requirements. At minimum usage, current milling capacity could be exceeded in 1980; maximum usage would advance the negative imbalance to 1979. Thus, shutting down the mill would advance the negative imbalance to early 1979.

Table B.1. "National Energy Outlook" Forecast of Nuclear Capacity

Year	Gigawatts
1976	29.2
1977	35.7
1978	42.2
1979	53.2
1980	60.0
1981	68.6
1982	88.5
1983	112.5
1984	126.8
1985	142.0

*A 1000-MWe reactor will require ∿ 22 MT of uranium fuel per year at a PF of 0.6 and ∿ 30 MT uranium fuel for PF 0.8. For a 3% enriched fuel, and 0.25 tails assay, MT of fuel converts to tons of U_3O_3 as follows: (MT of fuel) (7.9) = tons U_3O_3.

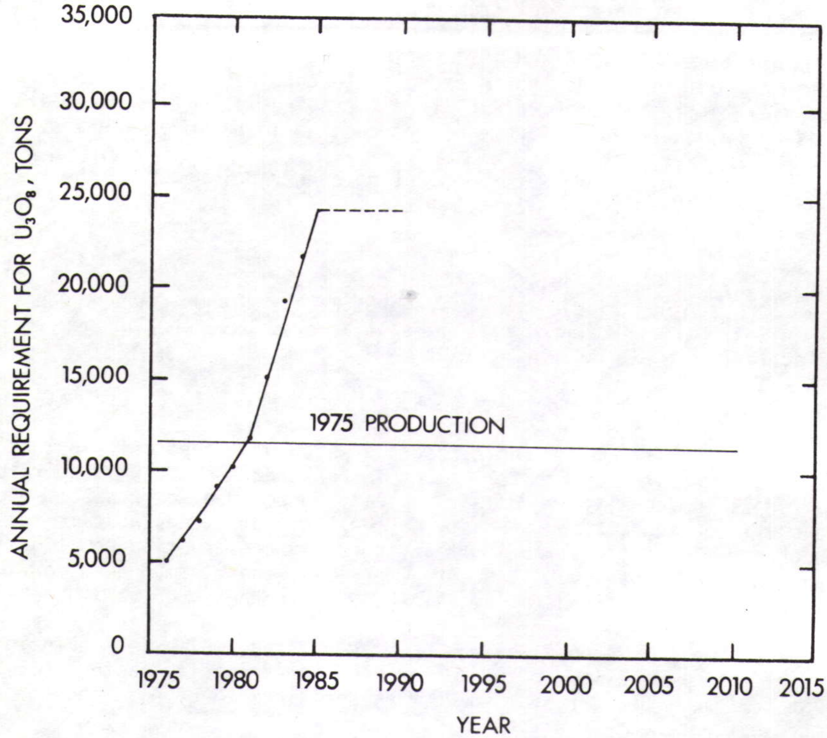


Fig. B.2. Minimum Annual U_3O_8Requirements.

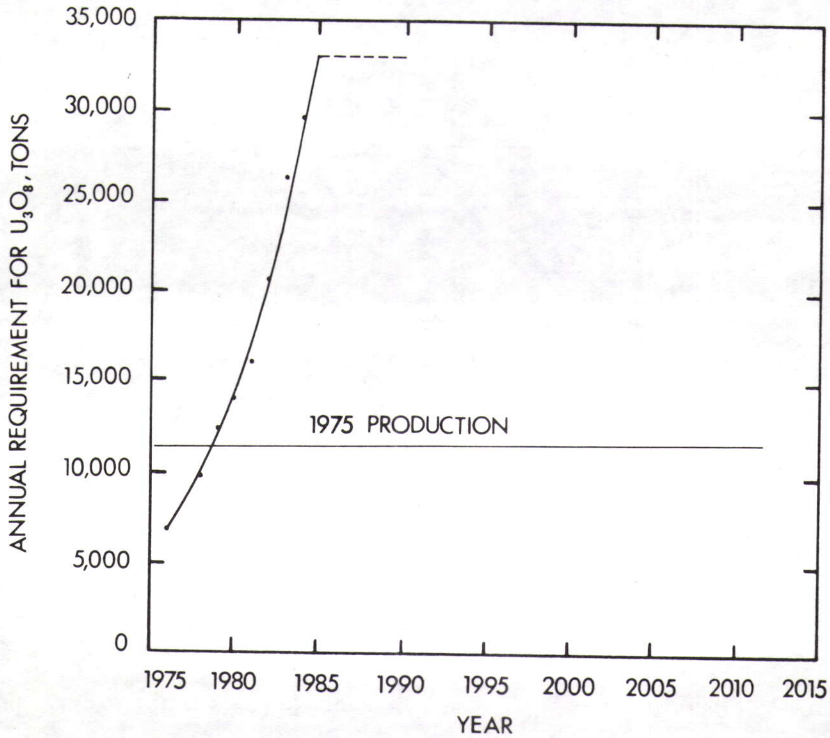


Fig. B.3. Maximum Annual U_3O_8Requirements.

References

1. "National Energy Outlook, 1976," Federal Energy Administration, 1976.

2. NRC Yellow Book, NUREG 00306, U. S. Nuclear Regulatory Commission, July 1976.

APPENDIX C. DETAILED RADIOLOGICAL ASSESSMENT

When evaluated in conjunction with Sections 3.2.6 and 4.7, the data presented in Appendix C permit detailed analysis of the radiological impact of the Atlas project and permit complete review and verification by qualified radiological scientists. Calculations of radiation doses have been made for radionuclides and receptors around the site.

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APPENDIX C-1. GENERAL CHARACTERISTICS

Table C-1.1. Principal Parameters and Conditions Used in Radiological Assessment of the Atlas Minerals Processing Facilities[a]

Parameter	Processing Circuit	
	Alkaline-Leach	Acid-Leach
Ore quality, U_3O_8	0.2%	0.25%
Ore activity, Ra-226	560	700 pCi/g
Ore activity, Th-230	560	700 pCi/g
Plant factor[b]	1	1
Ore process rate	1.9×10^5	2.0×10^5 MT/yr
Extraction efficiency		94%
Yellowcake yield		835 MT/yr
Yellowcake quality, U_3O_8		90%
Total tailings area		4.7×10^5 m^2
Tailings pond area		2.2×10^5 m^2
Tailings density		1.6 g/cm^3
Radon release rate from tailings		650 pCi/m^2 sec
Fraction U to tailings		0.06
Fraction Th to tailings		0.95
Fraction Ra to tailings		0.998
Mill water throughput		9.6×10^4 m^3/yr
Ore pad area		4.0×10^4 m^2

[a]The anticipated future ore throughput will be equal to the present ore input through 1997.

[b]The plant operates 365 days/yr.

Table C-1.2. Average Annual Emissions (curies) at the Atlas Minerals Milling Operation, 1977-1997[a,b]

Source	Nuclide				
	U-238	Th-230	Ra-226	Pb-210	Rn-222
Ore pad, feeder, crusher, grinder, and ore bin[c]	9×10^{-3}	9×10^{-3}	9×10^{-3}	9×10^{-3}	5.5×10^{1}
Yellowcake dryer	1×10^{-1}	3×10^{-3}	1×10^{-3}	1×10^{-3}	--
Tailings[c,d]	2×10^{-4}	4×10^{-3}	4×10^{-3}	4×10^{-3}	5×10^{3}

[a]For releases after stabilization and reclamation, see Section 10.

[b]It is assumed that the activity in the ore is in secular equilibrium for long-lived radionuclides.

[c]Particulate suspension is dependent on the sand-slime ratio and specific wind field over the tailings. Estimation of the source term from this pathway is based on an assumed particulate suspension ratio, η_i =

$$\eta_i = \left[\frac{((\text{pCi/m}^2\text{-sec) in air from the surface suspension})}{(\text{pCi/g of each radionuclide (i) in the tailings})}\right]$$

$$\eta_i = 10^{-5} \text{ (in g } (\text{m}^2 \times \text{sec})^{-1}) .$$

[d]Radon is assumed to be released only from the dry beach areas (2.4×10^5 m^2); the value given is for the 20th year of operation.

APPENDIX C-2. EFFECTIVE DISPERSION FACTORS FOR U-238

Table C-2.1. Effective Dispersion Factors for U-238, sec/m^3[a]

Distance, km	N	NE	E	SE	S	SW	W	NW
0.25	0.12E-03	0.56E-04	0.53E-04	0.17E-04	0.19E-04	0.35E-05	0.43E-04	0.74E-04
0.50	0.42E-04	0.15E-04	0.14E-04	0.50E-05	0.58E-05	0.92E-06	0.14E-04	0.23E-04
1.00	0.10E-04	0.46E-05	0.44E-05	0.15E-05	0.16E-05	0.29E-06	0.35E-05	0.60E-05
2.00	0.34E-05	0.15E-05	0.15E-05	0.46E-06	0.54E-06	0.94E-07	0.12E-05	0.20E-05
3.00	0.18E-05	0.82E-06	0.79E-06	0.25E-06	0.29E-06	0.51E-07	0.62E-06	0.11E-05
5.00	0.85E-06	0.39E-06	0.38E-06	0.12E-06	0.14E-06	0.24E-07	0.30E-06	0.51E-06
10.00	0.33E-06	0.15E-06	0.14E-06	0.45E-07	0.52E-07	0.90E-08	0.12E-06	0.20E-06

[a]Distances and directions are from the Atlas Mill radioactive effluent source.

APPENDIX C-3. RADIONUCLIDE DEPOSITION, BASED ON UDAD CODE

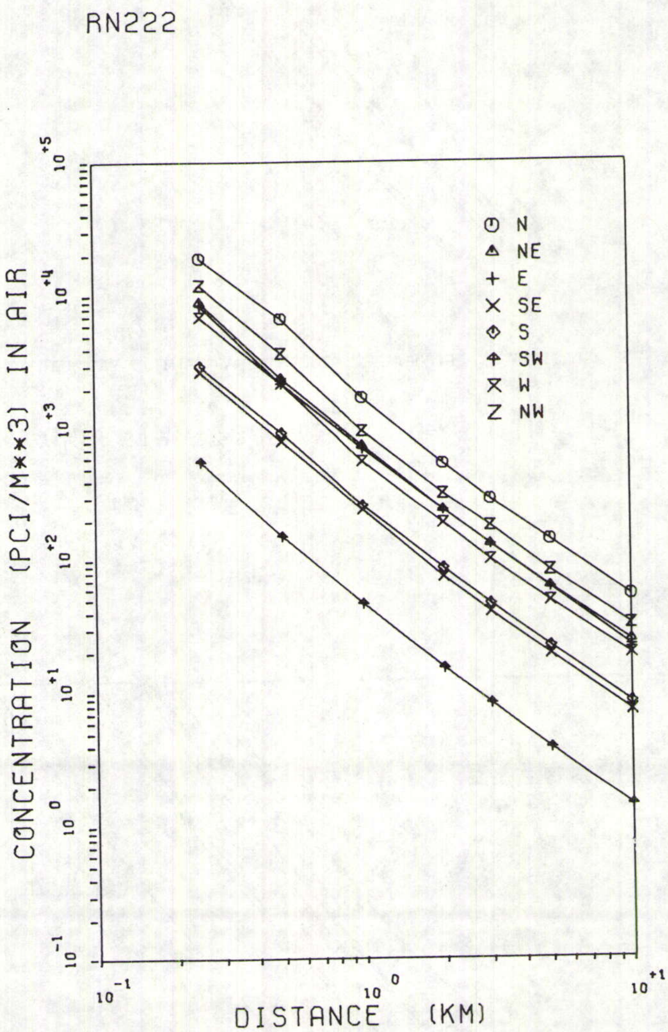

Fig. C-3.1. Computed Concentration of Rn-222 in Air.

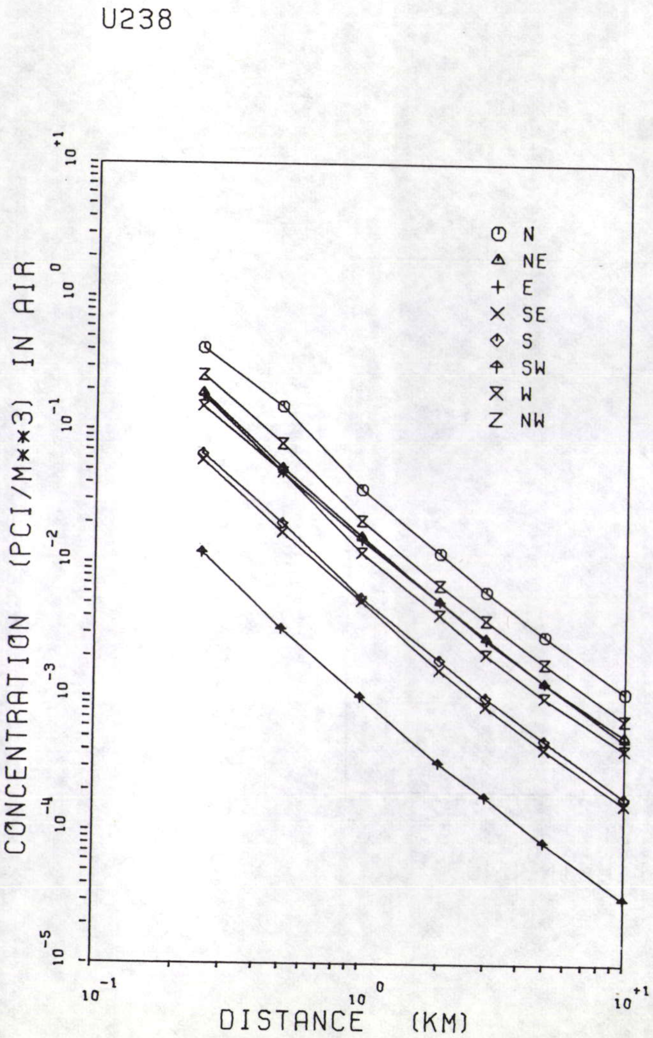

Fig. C-3.2. Computed Concentration of U-238 in Air.

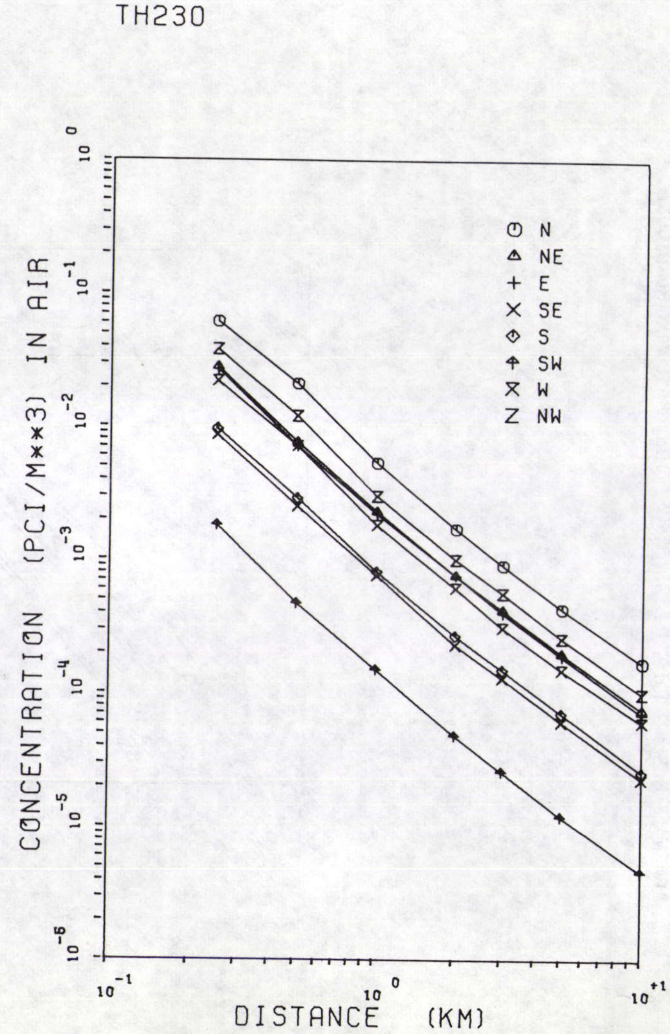

Fig. C-3.3. Computed Concentration of Th-230 in Air.

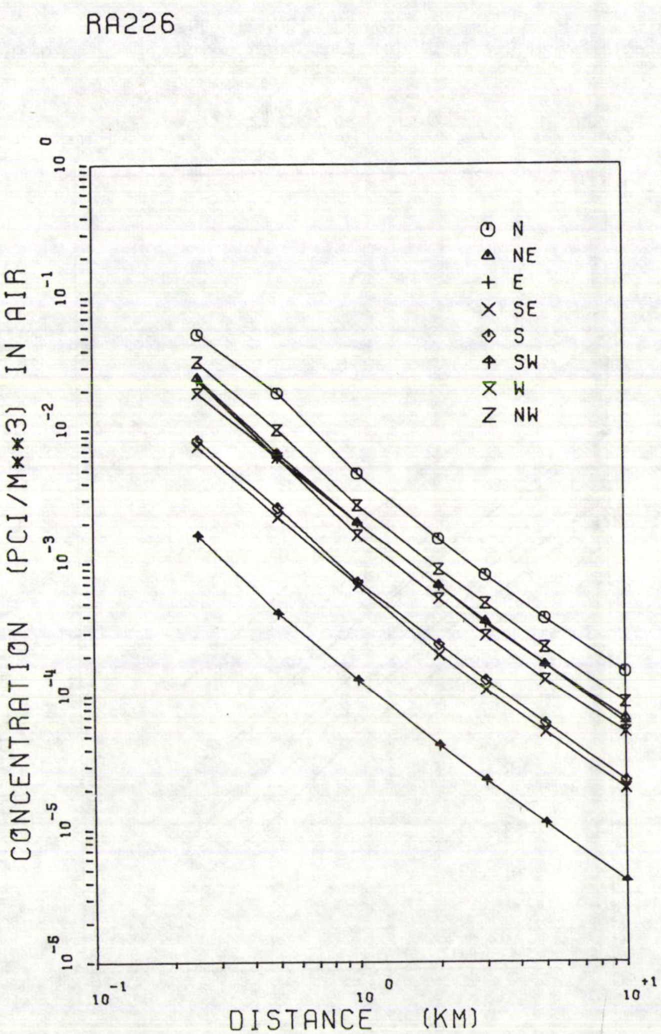

Fig. C-3.4. Computed Concentration of Ra-226 in Air.

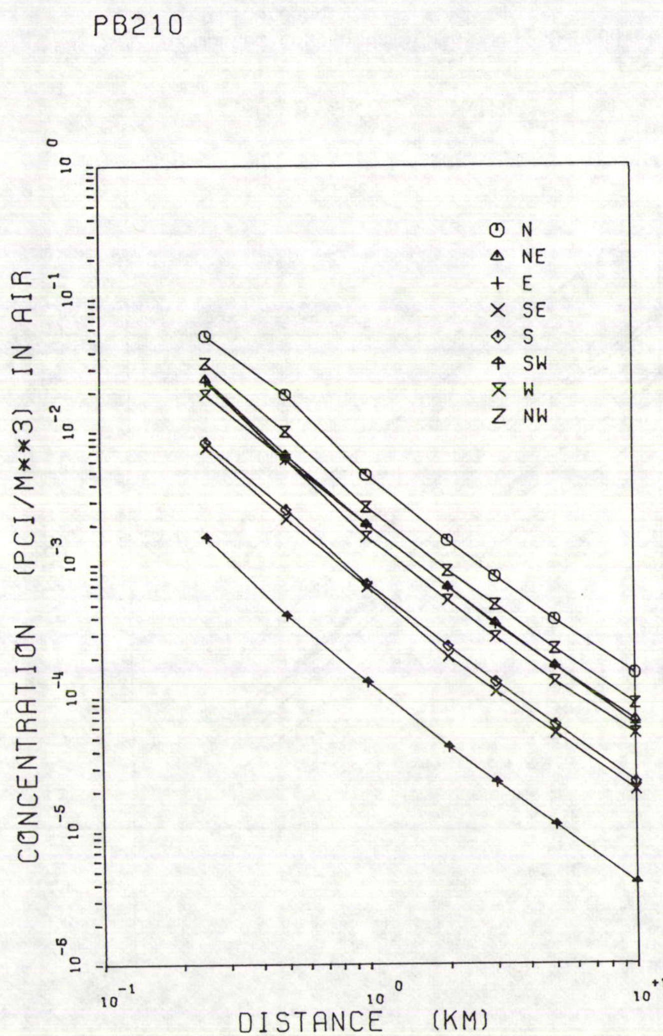

Fig. C-3.5. Computed Concentration of Pb-210 in Air.

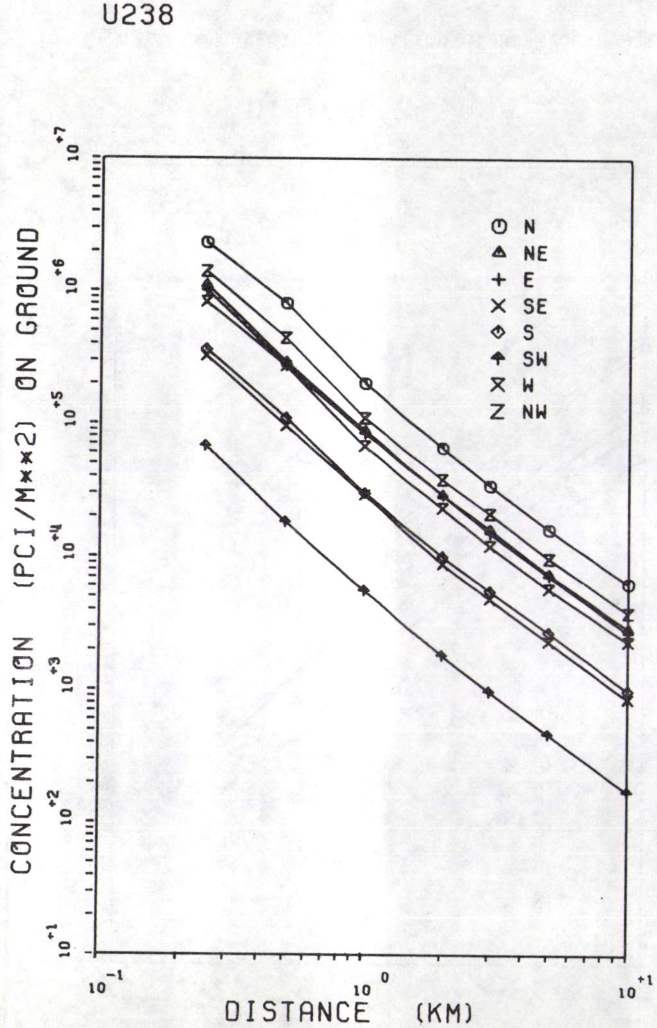

Fig. C-3.6. Computed Concentration of U-238 Deposited on the Ground.

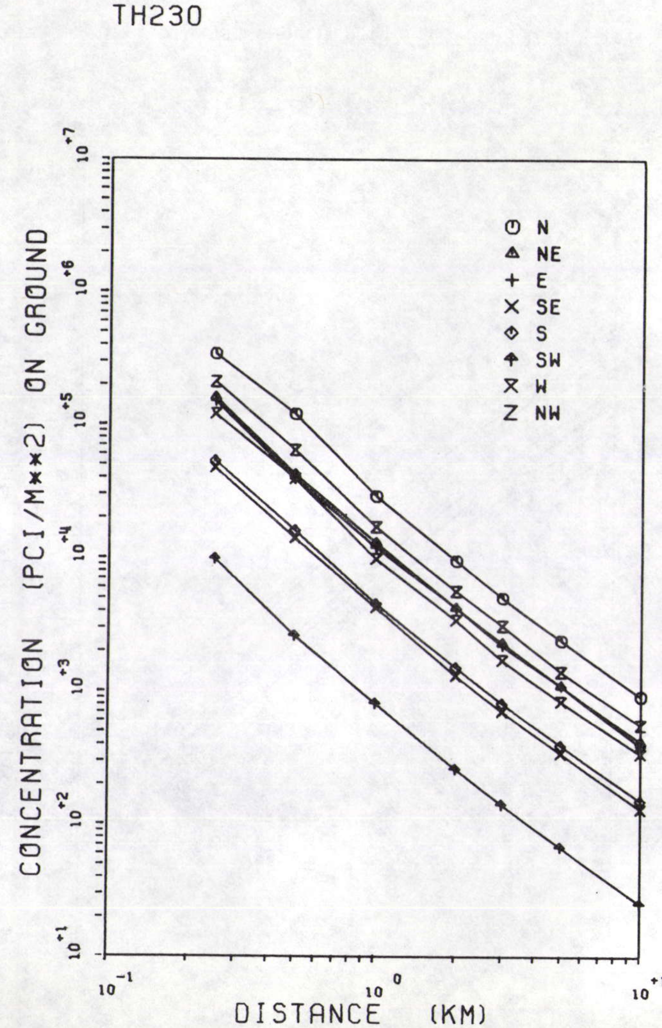

Fig. C-3.7. Computed Concentration of Th-230 Deposited on the Ground.

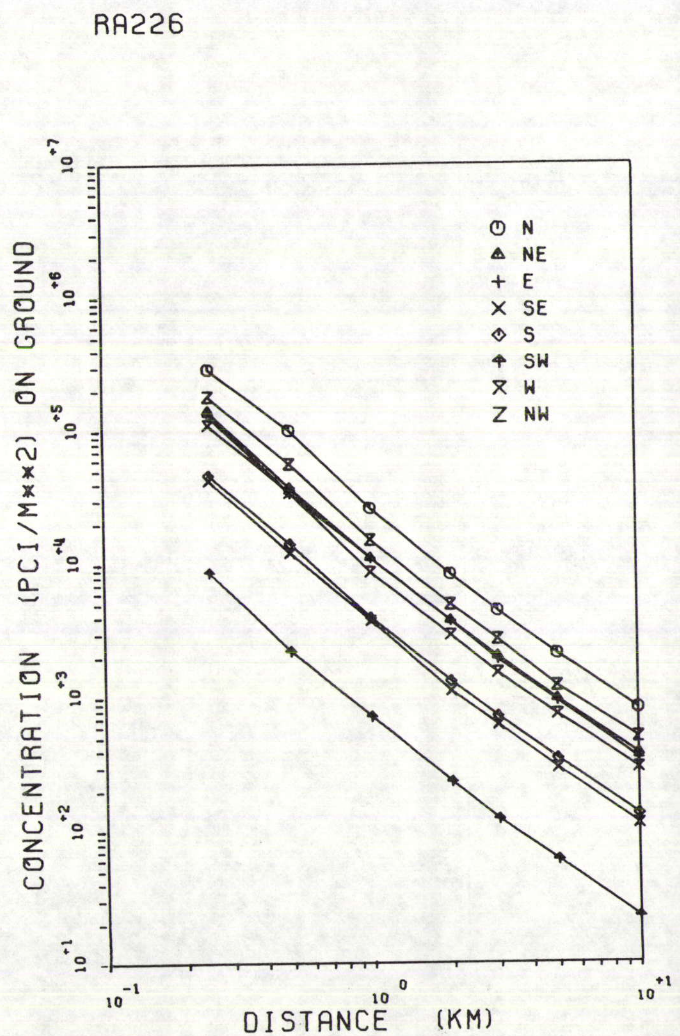

Fig. C-3.8. Computed Concentration of Ra-226 Deposited on the Ground.

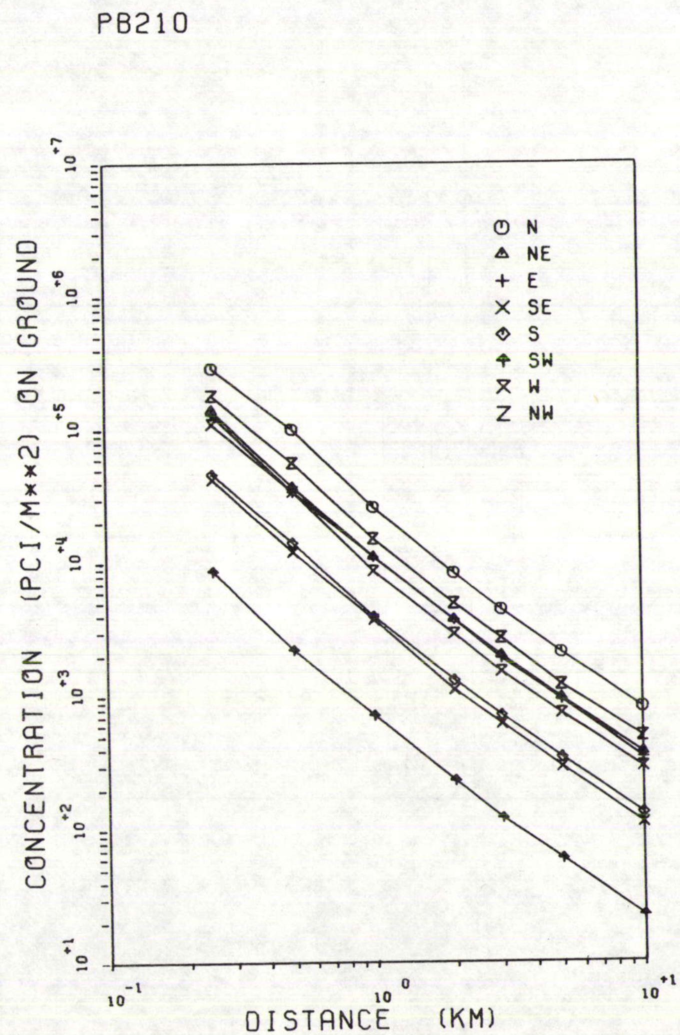

Fig. C-3.9. Computed Concentration of Pb-210 Deposited on the Ground.

APPENDIX C-4. DOSE COMMITMENTS FROM INHALATION, FOR SELECTED RADIONUCLIDES AND RECEPTORS

Table C-4.1. Dose Commitments, mrem/yr

Receptor	Radionuclides				
	U-238 and U-234	Th-230	Ra-226	Pb-210	Total
Tex's Tour Center (0.8 km E)					
Whole body	0.04	0.48	0.88	0.04	1.44
Bone	0.84	17.36	8.76	1.28	28.24
Lung	66.24	5.88	1.2	0.28	73.6
Permanent residents at Arches National Park (2.4 km NW)					
Whole body	0.01	0.1	0.2	7.5×10^{-3}	0.3
Bone	0.2	3.5	1.8	0.3	5.8
Lung	13	1.2	0.2	5.5×10^{-2}	14.5
Nearest resident with ingestion pathway (2.7 km SE)					
Whole body	2.0×10^{-3}	2.0×10^{-2}	3.7×10^{-2}	1.5×10^{-3}	5.6×10^{-2}
Bone	3.3×10^{-2}	0.67	0.34	5.2×10^{-2}	1.1
Lung	2.69	0.22	4.8×10^{-2}	1.1×10^{-2}	3.0
Town of Moab (5 km SE)					
Whole body	8.4×10^{-4}	7.8×10^{-3}	1.5×10^{-2}	6.0×10^{-4}	2.4×10^{-2}
Bone	1.3×10^{-2}	0.3	0.01	2.1×10^{-2}	0.4
Lung	1.1	0.1	1.9×10^{-2}	4.0×10^{-3}	1.2

APPENDIX C-5. FOOD PATHWAY - MEAT

Radioisotopes can enter the human body through the ingestion of meat containing radioactive materials. Radioisotopes enter the meat-ingestion pathway by direct deposition on, and by uptake through, the roots of grass used as feed for beef cattle.

The doses calculated were annual dose commitments (i.e. the doses integrated for 50 years from one year's ingestion of beef). The dosage was calculated on the basis of the following assumptions:

- Mill operating period (deposition and contamination period) = 20 years
- Soil density = 1.5 g/cm^3
- Soil depth for mixing = top 8 inches (20 cm)
- Total mixing-layer density thickness = 30 g/cm^2
- Weathering-removal half-life of deposited radioisotopes = 13 days
- Percentage of deposition total taken up by grass = 30%
- Grass density = 440 g/m^2
- Average exposure period of grass prior to being consumed by cattle = 90 days
- Fraction of year cattle graze on this pasture = 0.5
- Individual daily intake of beef by area resident = 250 g/day.

The concentration of isotopes in pasture grass resulting from deposition on the soil is estimated as:

$$C_{sv} = \frac{C_s \times B_{sv}}{\rho_s} \tag{1}$$

where:

C_{sv} = concentration of isotopes from soil in the grass, pCi/g;

C_s = concentration of isotopes on the soil, pCi/m^2;

ρ_s = soil surface density = 3×10^5 g/m^2; and

B_{sv} = the transfer factor given in Table C-5.1 for transfer of isotopes from soil to grass, pCi/g-grass/pCi/g-soil.

The expression for the concentration on grasses is:

$$C_{av} = 8.64 \times 10^4 \times \frac{C_a\ V_d\ f_v\ (1 - \exp(-\lambda_{wr} t_c))}{D_v\ (\lambda_{wr})} \tag{2}$$

where:

C_{av} = concentration of isotope in grass from direct deposition, pCi/g;

C_a = concentration of isotope in air, pCi/m^3;

λ_{wr} = $\lambda r + \lambda w$ = effective removal rate, day^{-1};

D_v = grass density = 440 g/m^2;

f_v = fraction taken up by grasses, 0.3;

t_c = average grass exposure period, 90 days;

V_d = deposition velocity, 0.01 m/sec; and

8.64×10^4 = conversion factor from day to second, sec-day^{-1}.

For a given location and animal feed consumption pattern, the concentration of isotope in a cattle's feed is estimated as:

$$C_f = f_p \, f_g \, C_v \exp(-\lambda_r t_e) + (1 - f_p \, f_g) \, C_t \exp(-\lambda_r t_s) \qquad (3)$$

where:

C_f = concentration of isotope in the cattle feed, pCi/g;

$C_v = C_{sv} + C_{av}$ = concentration of isotope in pasture grass, pCi/g;

f_p = fraction of pasture grass in daily feed of grazing animal = 1.0;

f_g = fraction of the year that cattle graze on pasture = 0.5;

C_t = concentration in feed at time of storage, pCi/g = 0.0;

t_e = delay time between deposition on pasture grass and consumption by cattle = 0.0; and

t_s = delay time between harvest of stored grass and consumption by cattle = 90 days.

The concentrations in beef are then given by:

$$C_b = F_f \, R_c \, C_f \exp(-\lambda_r t_t) \qquad (4)$$

where:

C_b = concentration of isotope in meat, pCi/g;

F_f = feed to beef product transfer factor, given in Table C-5.1, pCi/kg/pCi/D;

R_c = animals's rate of feed consumption = 50 kg/day for beef cattle; and

t_t = transport time from food production to consumption by man = 0.0.

The doses to man resulting from the consumption of meat containing radioactive materials are calculated on the basis of an ICRP publication on permissible doses of internal radiation.[3]

Table C-5.1. Stable Element Transfer Data[4]

	U	Th	Ra	Pb
B_{sv}	2.5×10^{-3}	4.2×10^{-3}	3.1×10^{-4}	6.8×10^{-2}
F_f (D/kg)	3.4×10^{-4}	2.0×10^{-4}	3.4×10^{-2}	2.9×10^{-4}

References for Appendix C-5

1. "Final Environmental Statement Concerning Proposed Rulemaking Action," Vol., I, Annex 6B, Directorate of Regulatory Standards, WASH-1258, U. S. Atomic Energy Commission, 1973.

2. J. T. Reid, "Forages for Dairy Cattle," in "Forages: The Science of Grassland Agriculture," M. F. Heath et al., eds., Ames, IA, Iowa State University Press, 1973.

3. International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation, 1959.

4. "Regulatory Guide 1.109, Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents For the Purpose of Evaluating Compliance With 10 CFR Part 50," Appendix I, U. S. Nuclear Regulatory Commission, 1976.